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TITLE: PIEZO RESISTANCE CHANGE SENSOR, AND MODULE, APPARATUS WITH VIBRATION DETECTING FUNCTION, PHYSICAL AMOUNT DETECTOR FOR BOILER, PHYSICAL AMOUNT DETECTOR FOR GAS AND ABNORMAL CONDITION DETECTOR

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Sakata et al

INVENTOR-INFORMATION:

NAME	COUNTRY
SAKATA, MINORU	
KAWABATA, TATSUHISA	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
OMRON CORP	N/A

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ABSTRACT:

PURPOSE: To provide a piezo resistance change detecting sensor which has high sensitivity and high resolution and a wide detecting range, and moreover a using temperature limit of not lower than 150°C.

CONSTITUTION: A sensor movable part 3 is supported to an Si substrate 1 by a beam 4. A piezoelectric resistance 5 of bark Si is formed at the front layer of the beam 4. A dielectric isolation layer 6 of air is formed between the sensor movable part 3 and the beam 4, and the Si substrate 1. A dielectric isolation layer 7 of an SiO_2 film is formed in an area of the Si substrate 1 supporting the beam 4. In order to form the dielectric isolation layer 7, a current is fed into an HF aqueous solution after a p+ region 11 is formed in the **Si** substrate 1 by ion

implantation, thereby changing the p+ region 11 to a **porous Si** region 16A and a high **density porous Si** region 17A, and then both regions 16A, 17A are heated/oxidized to an SiO_2 region 16B and a high **density** SiO_2 region 17B and the SiO_2 region 16B is **removed by etching**.

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(71)出願人　000002945
オムロン株式会社
京都府京都市右京区花園土堂町10番地

(72)発明者　坂田　稔
京都府京都市右京区花園土堂町10番地　オムロン株式会社内

(72)発明者　川畑　達央
京都府京都市右京区花園土堂町10番地　オムロン株式会社内

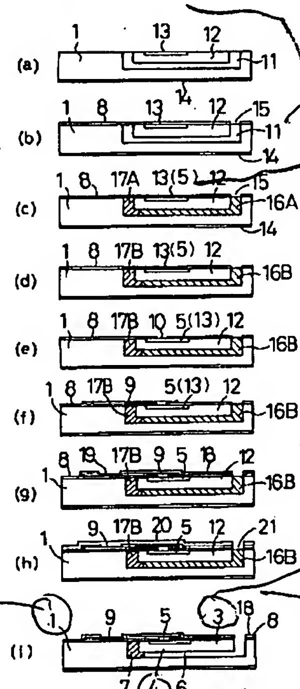
(74)代理人　弁理士　中野　雅房

(54)【発明の名称】　ピエゾ抵抗変化検出方式センサ、モジュール、振動検出機能付き機器、ボイラの物理量検出装置、気体用物理量検出装置及び異常状態検出装置

(57)【要約】

【目的】　①高感度、高分解能で、かつ、検出範囲が広く、しかも②１５０℃以上の使用温度限界を持つ、ピエゾ抵抗変化検出センサを提供する。

【構成】　センサ可動部３を、梁４によってＳｉ基板１に支持する。梁４の表層には、バルクＳｉからなるピエゾ抵抗５が形成される。センサ可動部３及び梁４とＳｉ基板１との間は、空気からなる誘電分離層６が形成され、Ｓｉ基板１の梁４を支持する領域は、ＳｉＯ$_2$膜からなる誘電分離層７が形成されている。この誘電分離層７は、イオン注入によってＳｉ基板１にｐ$^+$領域１１を形成した後、ＨＦ水溶液中にて電流を流すことにより、ｐ$^+$領域１１を多孔質Ｓｉ領域１６Ａ及び高密度多孔質Ｓｉ領域１７Ａに変化させ、ついで両領域１６Ａ，１７Ａを熱酸化させてＳｉＯ$_2$領域１６Ｂ及び高密度ＳｉＯ$_2$領域１７Ｂに変化させ、ＳｉＯ$_2$領域１６Ａをエッチング除去することにより形成される。



n-type Si

porous Si

Sensor

etch away porous Si

Si wafer

beam

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【特許請求の範囲】

【請求項１】　基板に支持されたセンサ可動部の変位をピエゾ抵抗によって検出するピエゾ抵抗変化検出方式センサにおいて、
バルクシリコンからなる前記ピエゾ抵抗と前記基板とを、多孔質シリコンを熱酸化させて形成した酸化膜によって誘電分離したことを特徴とするピエゾ抵抗変化検出方式センサ。

【請求項２】　前記センサ可動部に重り部を形成したことを特徴とする請求項１に記載のピエゾ抵抗変化検出方式センサ。

【請求項３】　前記センサ可動部に、１個もしくは複数個の開口部を設けたことを特徴とする請求項１又は２に記載のピエゾ抵抗変化検出方式センサ。

【請求項４】　前記センサ可動部を封止したことを特徴とする請求項１，２又は３に記載のピエゾ抵抗変化検出方式センサ。

【請求項５】　前記封止内部を減圧していることを特徴とする請求項４に記載のピエゾ抵抗変化検出方式センサ。

【請求項６】　前記ピエゾ抵抗の上面に、誘電体膜を挟んで金属やドーピングされたポリシリコンなどの導電材料からなる導電層を形成し、この導電層を基板と同電位にしたことを特徴とする請求項１，２，３，４又は５に記載のピエゾ抵抗変化検出方式センサ。

【請求項７】　前記ピエゾ抵抗の上に熱伝導率の良好な熱良導体層を直接に形成したことを特徴とする請求項１，２，３，４，５又は６に記載のピエゾ抵抗変化検出方式センサ。

【請求項８】　前記基板にセンサ可動部の変形を制限するためのストッパを設けたことを特徴とする請求項１，２，３，４，５，６又は７に記載のピエゾ抵抗変化検出方式センサ。

【請求項９】　前記センサ可動部を弾性支持する支持部に前記ピエゾ抵抗を設け、ピエゾ抵抗の近傍において前記支持部に切り欠き部もしくは開口部を設けたことを特徴とする請求項１，２，３，４，５，６，７又は８に記載のピエゾ抵抗変化検出方式センサ。

【請求項１０】　前記センサ可動部を弾性支持する支持部と前記基板上に、抵抗値検出回路を設けたことを特徴とする１，２，３，４，５，６，７，８又は９に記載のピエゾ抵抗変化検出方式センサ。

【請求項１１】　前記ピエゾ抵抗と逆温度特性の抵抗を前記基板上に設け、この抵抗で前記抵抗値検出回路の一部を構成することによって温度による特性変化を補償させるようにしたことを特徴とする請求項１０に記載のピエゾ抵抗変化検出方式センサ。

【請求項１２】　前記基板上にオフセット抵抗ないし感度調整用抵抗を設け、このオフセット抵抗ないし感度調整用抵抗で前記抵抗値検出回路の一部を構成したことを特徴とする請求項１０に記載のピエゾ抵抗変化検出方式センサ。

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【請求項１３】　前記基板に複数のセンサ可動部及び複数のピエゾ抵抗を設けたことを特徴とする１，２，３，４，５，６，７，８，９，１０，１１又は１２に記載のピエゾ抵抗変化検出方式センサ。

【請求項１４】　パワーＩＣのような発熱部品と請求項１，２，３，４，５，６，７，８，９，１０，１１，１２又は１３に記載のピエゾ抵抗変化検出方式センサとを組合せたことを特徴とするモジュール。

【請求項１５】　請求項１，２，３，４，５，６，７，８，９，１０，１１，１２又は１３に記載のピエゾ抵抗変化検出方式センサを原動機、電動機、発電機、ディスクブレーキ、工作機等の機器に取り付けたことを特徴とする振動検出機能付き機器。

【請求項１６】　請求項１，２，３，４，５，６，７，８，９，１０，１１，１２又は１３に記載のピエゾ抵抗変化検出方式センサをボイラに直接取り付け、ボイラの振動や圧力等の物理量を検出させるようにしたことを特徴とするボイラの物理量検出装置。

【請求項１７】　請求項１，２，３，４，５，６，７，８，９，１０，１１，１２又は１３に記載のピエゾ抵抗変化検出方式センサを蒸気等の高温気体の通過する管内に取り付け、高温気体の圧力や流速等の物理量を検出させるようにしたことを特徴とする気体用物理量検出装置。

【請求項１８】　請求項１，２，３，４，５，６，７，８，９，１０，１１，１２又は１３に記載のピエゾ抵抗変化検出方式センサと、
前記センサの検出信号に対してファジイ処理を行なうことにより、異常を検出する信号処理手段とを備えたことを特徴とする異常状態検出装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、ピエゾ抵抗変化検出方式センサに関する。特に、力、圧力、加速度、流速、傾斜角等の物理量を検出するための各種センサとして応用されるピエゾ抵抗変化検出方式センサに関する。さらに、そのピエゾ抵抗変化検出方式センサを備えたモジュール、振動検出機能付き機器、ボイラの物理量検出装置、気体用物理量検出装置および異常状態検出装置に関する。

【０００２】

【従来の技術】従来のピエゾ抵抗変化検出方式センサをピエゾ抵抗の材質という点から見た場合、抵抗材料にポリシリコンを使用したものと、バルクシリコンを使用したものとに大別される。

【０００３】（ポリシリコンを使用したピエゾ抵抗変化検出方式センサ）ピエゾ抵抗の材質としてポリシリコンを使用したピエゾ抵抗変化検出方式センサにあっては、

その製造プロセス上、ピエゾ抵抗とシリコン基板との間に分離層を形成して誘電分離することが容易であるため、シリコン基板と誘電分離されたピエゾ抵抗が用いられている。従って、当該センサでは、分離層の絶縁破壊が発生しない限り、シリコン基板とピエゾ抵抗間に電流が流れる恐れがなく、１５０℃以上の高温でも使用することができる。つまり、高温側での使用温度限界が高いという長所を有している。

【０００４】しかしながら、ポリシリコンを用いたピエゾ抵抗（以下、ポリシリコン抵抗という）は、バルクシリコンを用いたピエゾ抵抗（以下、バルクシリコン抵抗という）と比較して、ゲージ率（歪み量に対する抵抗変化の割合）が小さく、通常、同じ歪み量に対してバルクシリコン抵抗の１／５程度の抵抗変化しか起きない。このため、同じ構成および形状のピエゾ抵抗変化検出方式センサを製作した場合、ポリシリコン抵抗を用いたピエゾ抵抗変化検出方式センサは、感度、分解能ともにバルクシリコン抵抗を使用したピエゾ抵抗変化検出方式センサに劣っていた。

【０００５】また、ポリシリコン抵抗の破壊歪みはバルクシリコン抵抗よりも小さいので、検出時の最大歪みを低く設計することになり、検出感度の低さと合せると圧力や加速度等の入力物理量の検出範囲が狭くなってしまうという欠点があった。

【０００６】さらに、バルクシリコン抵抗と比較してポリシリコン抵抗は抵抗温度係数（ＴＣＲ）が大きい（通常、バルクシリコン抵抗の５倍程度）ので、温度による抵抗値変化が大きい。このため、ポリシリコン抵抗を用いたピエゾ抵抗変化検出方式センサは、温度特性が悪く、温度変化に対して不安定であった。

【０００７】（バルクシリコンを使用したピエゾ抵抗変化検出方式センサ）バルクシリコンを使用したピエゾ抵抗変化検出方式センサでは、上記のようにバルクシリコン抵抗のゲージ率がポリシリコン抵抗と比較して大きいので、感度及び分解能が高く、また、破壊歪みも大きいので検出範囲を広くすることができるという長所がある。さらに、バルクシリコン抵抗の抵抗温度係数が小さいため、温度特性も良好である。

【０００８】しかしながら、バルクシリコン抵抗を用いたピエゾ抵抗変化検出方式センサでは、バルクシリコン抵抗とシリコン基板との分離をｐ－ｎ接合で行なっており、しかも、ゲージ率等のピエゾ抵抗の特性はｐ型の方が良いためにシリコン基板のｎ層を高電位に維持するのが一般的であるので、高温環境下（１５０℃以上）ではｐ－ｎ接合の分離層を挟んでリーク電流が流れる易く、高温側の使用温度限界が約１５０℃と低い欠点があった。

【０００９】このため、①高感度、高分解能で、かつ、検出範囲が広いという特性の良さと、②高温側において高い使用温度限界を持つという、２つの要求を同時に満たすピエゾ抵抗変化検出方式センサが望まれている。

【００１０】そこで、この２つの要求を同時に満足させるため、図２４に示すような製造方法が提案されている。この製造方法を図２４に従って説明する。図２４（ａ）に示すものは２枚のＳｉ基板（シリコンウエハ）８１，８２であって、一方のＳｉ基板８１の下面にホウ素等のｐ型イオンを打込むことによってピエゾ抵抗８５となるp^{++}層８３が形成され、他方のＳｉ基板８２の上面には酸化膜（SiO_2膜）８４が形成されている。このＳｉ基板８２の上にＳｉ基板８１を重ねて互いに接合させ（図２４（ｂ））、接合した後、上のＳｉ基板８１をＫＯＨ等のアルカリエッチャントを用いてエッチング除去する。このときp^{++}層８３はエッチングレートがＳｉ基板８１よりも小さいので、エッチングされることなくＳｉ基板８２の上に残り、図２４（ｃ）に示すように、酸化膜８４の上にピエゾ抵抗８５が形成される。

【００１１】この後、Ｓｉ基板８２の下面に低圧ＣＶＤ法によってＳｉＮ膜を形成し、ＳｉＮ膜をパターニングすることによって異方性エッチング用のマスク８６を形成する（図２４（ｄ））。また、Ｓｉ基板８２の上面には、ピエゾ抵抗８５に導通させて金属配線８７を施し（図２４（ｅ））、さらに、ＰＳＧ等のガラス材料によってパッシベーション膜８８を形成する（図２４（ｆ））。ついで、Ｓｉ基板８２に下面側から異方性エッチングを施すことにより、マスク８６から露出している部分を梁８９の厚さまで削り込む（図２４（ｇ））。さらに、梁８９となる部分を残して他の薄肉部分をエッチングによって開口させることにより、梁８９及びセンサ可動部９０が形成される（図２４（ｈ））。

【００１２】

【発明が解決しようとする課題】上記のようにして製造された加速度センサ９１にあっては、梁８９の上面に酸化膜８４で隔ててバルクシリコンからなるピエゾ抵抗８５が形成されている。従って、ピエゾ抵抗８５とＳｉ基板８２とは酸化膜８４によって絶縁されており、ピエゾ抵抗８５とＳｉ基板８２との間にリーク電流が流れる心配がなく、１５０℃以上の高温においても使用可能となる。

【００１３】しかしながら、２枚のＳｉ基板８１，８２を接合した後、上のＳｉ基板８１をエッチングする場合、ピエゾ抵抗８５がアルカリエッチャントによってエッチングされることなく、図２４（ｃ）のように所定の厚みでピエゾ抵抗８５だけが残るようにするためには、p^{++}層８３（ピエゾ抵抗８５）へのイオン注入量を大きくする必要がある。ところが、p^{++}層８３へのイオン注入量を大きくしてエッチングされにくくすると、ゲージ率をあまり高くすることができなかった。そのため、高感度、高分解能で、検出範囲が広いといったバルクシリコン抵抗の長所を生かすことができなかった。

【００１４】また、１つの加速度センサ９１を得るため

に2枚のＳｉ基板８１，８２が必要となり、さらに、２枚のＳｉ基板８１，８２を接合する工程と、接合されたＳｉ基板８１，８２を約１枚分の厚みになるまでシンニングする工程とが必要となり、製品の歩留りが悪く、コストが高くつくという欠点があった。

【００１５】従って、従来のピエゾ抵抗変化検出方式センサでは、①高感度、高分解能で、かつ、検出範囲が広いという特性の良さと、②高温側において高い使用温度限界を持つという、２つの要求を同時に満たすことができなかった。

【００１６】本発明は叙上の従来例の欠点に鑑みてなされたものであり、その目的とするところは、バルクシリコンからなるピエゾ抵抗及びセンサ可動部を酸化膜で基板と誘電分離することにより上記①と②の２つの要求を同時に満たすピエゾ抵抗変化検出方式センサを提供することにある。

【００１７】

【課題を解決するための手段】本発明のピエゾ抵抗変化検出方式センサは、バルクシリコンからなる前記ピエゾ抵抗と前記基板とを、多孔質シリコンを熱酸化させて形成した酸化膜によって誘電分離したことを特徴としている。

【００１８】また、上記ピエゾ抵抗変化検出方式センサにおいては、前記センサ可動部に重り部を形成してもよい。あるいは、前記センサ可動部に１個もしくは複数個の開口部を設けてもよい。さらに、前記センサ可動部を封止してもよい。その場合、封止内部を減圧してもよい。

【００１９】また、上記ピエゾ抵抗変化検出方式センサにおいては、前記ピエゾ抵抗の上面に、誘電体膜を挟んで金属やドーピングされたポリシリコンなどの導電材料からなる導電層を形成し、この導電層を基板と同電位にしてもよい。あるいは、前記ピエゾ抵抗の上に熱伝導率の良好な熱良導体層を直接に形成してもよい。

【００２０】また、上記ピエゾ抵抗変化検出方式センサにおいては、前記基板にセンサ可動部の変形を制限するためのストッパを設けてもよい。さらに、前記センサ可動部を弾性支持する支持部に前記ピエゾ抵抗を設け、ピエゾ抵抗の近傍において前記支持部に切り欠き部もしくは開口部を設けてもよい。

【００２１】また、上記ピエゾ抵抗変化検出方式センサには、抵抗値検出回路を設けることができる。その場合、前記ピエゾ抵抗と逆温度特性の抵抗を前記基板上に設け、この抵抗で前記抵抗値検出回路の一部を構成することによって温度による特性変化を補償させるようにしてもよい。あるいは、前記基板上にオフセット抵抗ないし感度調整用抵抗を設け、このオフセット抵抗ないし感度調整用抵抗で前記抵抗値検出回路の一部を構成してもよい。

【００２２】さらに、前記基板には、複数のセンサ可動部及び複数のピエゾ抵抗を設けてもよい。

【００２３】また、本発明のモジュールは、パワーＩＣのような発熱部品と上記ピエゾ抵抗変化検出方式センサとを組合せたことを特徴としている。

【００２４】また、本発明の振動検出機能付き機器は、上記ピエゾ抵抗変化検出方式センサを原動機、電動機、発電機、ディスクブレーキ、工作機等の機器に取り付けたことを特徴としている。

【００２５】また、本発明のボイラの物理量検出装置は、上記ピエゾ抵抗変化検出方式センサをボイラに直接取り付け、ボイラの振動や圧力等の物理量を検出させるようにしたことを特徴としている。

【００２６】また、本発明の気体用物理量検出装置は、上記ピエゾ抵抗変化検出方式センサを蒸気等の高温気体の通過する管内に取り付け、高温気体の圧力や流速等の物理量を検出させるようにしたことを特徴としている。

【００２７】また、本発明の異常状態検出装置は、上記ピエゾ抵抗変化検出方式センサと、前記センサの検出信号に対してファジイ処理を行なうことにより、異常を検出する信号処理手段とを備えたことを特徴としている。

【００２８】

【作用】本発明のピエゾ抵抗変化検出方式センサにあっては、バルクシリコンからなるピエゾ抵抗と基板とを酸化膜によって誘電分離しているので、約１５０℃以上の高温でもピエゾ抵抗と基板との間にリーク電流が流れることがなく、高温環境下での使用が可能になる。また、本発明にあっては、多孔質シリコンを熱酸化させることによって誘電分離用の絶縁膜を形成しているので、ピエゾ抵抗をセンサ可動部ないしその支持部分に埋め込んだ後、その周囲の領域を多孔質シリコン化し、さらに熱酸化することによって酸化膜を形成し、ピエゾ抵抗と基板とを誘電分離することができる。従って、２枚の基板を用いて一方の基板の酸化膜の上に他方の基板によってピエゾ抵抗を重ね、シンニングによってピエゾ抵抗を酸化膜の上に形成する従来例のように、製造工程においてピエゾ抵抗のゲージ率が低下することがない。この結果、バルクシリコン抵抗の利点である、感度及び分解能が高く、検出範囲が広いという長所を生かすことができる。この結果、①１５０℃以上の高温使用が可能で、かつ、②高感度、高分解能で、広い検出範囲と良好な温度特性を有するピエゾ抵抗変化検出方式センサを実現することができる。

【００２９】また、図２４に示した従来のピエゾ抵抗変化検出方式センサのように２枚の基板を必要とせず、１枚の基板から作製することができるので、コストも安価にすることができる。

【００３０】また、このピエゾ抵抗変化検出方式センサにおいて、センサ可動部に重り部を形成すれば、低入力レベルの検出物理量に対する感度を向上させることができる。

【0031】さらに、センサ可動部に1個もしくは複数個の開口部を設ければ、センサ可動部の変形時における空気抵抗を軽減することにより、センサ感度を向上させることができる。

【0032】また、前記センサ可動部を封止すれば、センサ可動部を汚染雰囲気と遮断することができ、耐環境性が向上する。その場合、封止内部を減圧しておけば、空気抵抗が減少してセンサ感度が向上する。

【0033】また、ピエゾ抵抗の上面に導電層を形成し、この導電層を基板と同電位にしておけば、電磁ノイズを受けにくくなり、ピエゾ抵抗変化検出方式センサのS／N比が向上する。

【0034】あるいは、ピエゾ抵抗の上に熱良導体層を直接に形成しておけば、ピエゾ抵抗内の温度傾斜が小さくなるため、ピエゾ抵抗からの抵抗出力誤差を小さくすることができる。

【0035】また、基板にセンサ可動部の変形を制限するためのストッパを設けておけば、センサ可動部の過大変位による破損を防止することができる。

【0036】さらに、センサ可動部を弾性支持する支持部に切り欠き部もしくは開口部を設ければ、切り欠き部もしくは開口部に応力集中が発生し、その結果同一入力に対する支持部の歪が大きくなってセンサ感度が向上する。

【0037】また、基板上にピエゾ抵抗の抵抗値を検出するための抵抗値検出回路を設ければ、別途抵抗値検出回路を必要とせず、抵抗値検出回路も含めたピエゾ抵抗変化検出方式センサをコンパクトにまとめることができる。さらに、その抵抗値検出回路内にピエゾ抵抗と逆温度特性の温度補償用抵抗を含ませておけば、温度変化に伴うピエゾ抵抗の出力変化と温度補償用抵抗の出力変化を互いに相殺させることができ、温度変化による検出誤差を小さくすることができる。あるいは、抵抗値検出回路にオフセット抵抗ないし感度調整用抵抗を設けておけば、抵抗値検出回路のオフセット値や検出感度を調整することができる。

【0038】また、同一基板に複数のセンサ可動部及び複数のピエゾ抵抗を設け、各センサ可動部の感度領域を少しずつ異ならせておけば、各センサ可動部の感度を重畳させることによって感度領域を広帯域化することができる。

【0039】また、本発明のピエゾ抵抗変化検出方式センサは上記のような長所を有しているので、パワーＩＣのような発熱部品を含むモジュール、ボイラ、高温気体の流れる管内などの高温環境下においても用いることができ、このような高温環境下でも高感度の検出を行なうことができる。

【0040】また、原動機、電動機、発電機、ディスクブレーキ、工作機等の機器に取り付けることによって、高感度で振動の検出を行なうことができ、さらに、この

検出信号を信号処理部でファジイ処理を行なうことにより異常を検出するようにすれば、高感度で高温環境下でも使用可能な異常検出装置を得ることができる。

【0041】

【実施例】図1は本発明の一実施例によるピエゾ抵抗変化検出方式の加速度センサＡを示す一部破断した斜視図である。1はｐ－Ｓｉ基板であって、Ｓｉ基板1の上面には矩形状の凹部2が凹設されている。n^-－バルクＳｉからなるセンサ可動部3は、宙に浮いた状態で凹部2内に納められており、2本の水平な梁4によってＳｉ基板1に支持されている。従って、センサ可動部3が加速度や振動、衝撃などを感じて変位すると、梁4が弾性変形する。梁4の表層には、p^+－バルクＳｉからなるピエゾ抵抗5が形成されており、ピエゾ抵抗5の抵抗変化として梁4の歪量を検出する。従って、ピエゾ抵抗5の抵抗値変化によってセンサ可動部3に加わる加速度や振動、衝撃等が検出される。

【0042】また、センサ可動部3、梁4及びピエゾ抵抗5とＳｉ基板1とは誘電分離層によって誘電分離されている。すなわち、センサ可動部3及び梁4とＳｉ基板1（凹部2内面）との間の空間には、空気（誘電体）からなる誘電分離層6が形成されている。さらに、凹部2の縁の梁4を支持している領域は、酸化シリコン（SiO_2）膜からなる誘電分離層7が形成されている。従って、センサ可動部3は、Ｓｉ基板1内に埋め込まれた誘電分離層7によって梁4の基端部を支持されたような構造となっており、センサ可動部3及び梁4はＳｉ基板1から完全に誘電分離されており、150℃以上の高温でもピエゾ抵抗5とＳｉ基板1との間にリーク電流が流れる恐れがない。

【0043】さらに、Ｓｉ基板1、センサ可動部3、梁4及びピエゾ抵抗5の表面は窒化シリコン（ＳｉＮ）からなるパッシベーション膜8によって覆われており、パッシベーション膜8の上に形成されたＡｌの金属配線9はパッシベーション膜8に開口したコンタクトホール10を通してピエゾ抵抗5の両端に電気的に接続されている。なお、この上にさらにＳｉＮからなるパッシベーション膜を形成してもよい。

【0044】つぎに、上記加速度センサＡの製造方法を説明する。この加速度センサＡ（図1の加速度センサとは金属配線の構造が若干異なる。）の製造方法を図2（ａ）～（ｉ）に示し、以下図2（ａ）～（ｉ）に従って当該製造方法を説明する。ｐ－Ｓｉ基板（シリコンウエハ）1の1個分のセンサ形成領域においては、図2（ａ）に示すように、Ｓｉ基板1の表面の誘電分離層6，7を形成しようとする領域にｐ型イオンをイオン注入してp^+領域11を形成し、このp^+領域11内のセンサ可動部3及び梁4を形成しようとする領域にｎ型イオンをイオン注入してn^+領域12を形成し、さらにn^+領域12内のピエゾ抵抗5を形成しようとする領域にｐ型

イオンをイオン注入してp^+領域１３を形成する。また、Ｓｉ基板１の裏面にｐ型ドーパントを拡散させてp^{++}層１４を形成する。ここで、p^{++}層１４は多孔質Ｓｉ形成時の裏面側コンタクト層となるものである。

【００４５】ついで、図２（ｂ）に示すように、Ｓｉ基板１の表面にＬＰＣＶＤ法（低圧ＣＶＤ法）によってＳｉＮを堆積させることによってパッシベーション膜８を形成し、当該パッシベーション膜８のp^+領域１１と接する部分の一部に窓１５を開口する。なお、このときＳｉ基板１の下面に堆積したＳｉＮは除去される。

【００４６】この後、Ｓｉ基板１をＨＦ（フッ化水素）水溶液に浸漬し、ＨＦ水溶液中においてＳｉ基板１のp^{++}層１４と対向電極（図示せず）間に電流を流すと、図２（ｃ）に示すように、p^+領域１１が多孔質Ｓｉ領域１６Ａに変化する。この際、一部が露出しているp^+領域１１には裏面コンタクト層となるp^{++}層１４から電流が流れて多孔質Ｓｉ領域１６Ａに変化するが、ピエゾ抵抗５であるp^+領域１３はパッシベーション膜（ＬＰＣＶＤ－ＳｉＮ）８でカバーされているため、裏面のp^{++}層１４からＨＦ水溶液中に流れる電流の経路にはならないので、多孔質化しない。また、このとき多孔質化される領域に流れる電流密度と多孔質Ｓｉ領域１６Ａの密度とは大略反比例の関係にあるので、この現象を利用し、p^+領域１１の露出側と反対側に高密度多孔質Ｓｉ領域１７Ａを形成する。従って、p^+領域１１のみが、多孔質Ｓｉ領域１６Ａもしくは高密度多孔質Ｓｉ領域１７Ａになる。多孔質Ｓｉ領域１６Ａ及び高密度多孔質Ｓｉ領域１７Ａを形成した後、Ｓｉ基板１を熱酸化させると、図２（ｄ）に示すように、Ｓｉ基板１に埋め込まれている多孔質Ｓｉ領域１６ＡはSiO_2領域１６Ｂに変化し、また、高密度多孔質Ｓｉ領域１７Ａは高密度SiO_2領域１７Ｂとなる。

【００４７】ついで、ピエゾ抵抗５（p^+領域１３）の両端において、図２（ｅ）に示すように、パッシベーション膜８にコンタクトホール１０を開口し、図２（ｆ）に示すように、パッシベーション膜８の上にＡｌによって所定パターンの金属配線９を形成すると共にコンタクトホール１０を通して金属配線９とピエゾ抵抗５とを電気的に接続する。さらに、図２（ｇ）に示すように、この上からプラズマＣＶＤ（ＰＥＣＶＤ）法によってＳｉＮを堆積させることによって金属配線保護用のパッシベーション膜１８を形成し、パッシベーション膜１８をパターニングして金属配線９の電極パッドとなる部分でコンタクトホール１９を開口し、パッシベーション膜１８を焼成する。

【００４８】この後、全体をレジスト膜２０によって覆うと共にSiO_2領域１６Ｂと対向する位置でレジスト膜２０に窓２１を開口してSiO_2領域１６Ｂの端部を露出させる。ついで、ＨＦ水溶液やＨＦ＋NH_4F水溶液等を用いてＢＯＥ（バッファ・オキサイド・エッチング）法によりSiO_2領域１６Ｂをエッチング除去し、エッチング除去後の空間によって誘電分離層６を形成すると共に、残ったn^+領域１２によってセンサ可動部３及び梁４を形成する。また、エッチングすることなく残した高密度SiO_2領域１７Ｂによって誘電分離層７を形成する。このとき、高密度SiO_2領域１７Ｂは、他の領域に比較してエッチングレートが低いので、一定のエッチング距離の精度に対してエッチング時間の許容幅が大きくなり、ＢＯＥエッチングによるセンサ可動部３の形状バラツキを小さくできる。

【００４９】この製造方法によれば、ＨＦ水溶液中における多孔質シリコン形成プロセス、多孔質Ｓｉ酸化プロセス、酸化Ｓｉエッチングプロセスを組合わせることにより、Ｓｉ基板１にバルクＳｉのピエゾ抵抗５、センサ可動部３、空間及び高密度SiO_2膜１７Ｂからなる誘電分離層６，７を形成することができ、①１５０℃以上の高温使用が可能、かつ、②高感度、高分解能で、広い検出範囲と良好な温度特性を持つピエゾ抵抗変化検出方式の加速度センサＡを作製することができる。

【００５０】また、この製造方法によれば、ピエゾ抵抗５を梁４内に設け、多孔質Ｓｉ領域１６Ａ，１７Ａを酸化させ、一部エッチングすることによって誘電分離層６，７を形成しているので、従来のシンニングプロセスによってピエゾ抵抗５を形成する方法のように、ゲージ率を小さくする要因が存在しない。従って、ピエゾ抵抗５のゲージ率を大きくすることができ、高感度、高分解能で、かつ検出範囲が広いという良好な特性を得ることができる。また、従来例のように２枚のＳｉ基板を必要とせず、その接合やシンニング等の工程も必要ないので、コストを安価にすることができる。

【００５１】図３に示すものは本発明の別な実施例による加速度センサＢを示す断面図である。この加速度センサＢにあっては、パッシベーション膜１８の上からセンサ可動部３の上に金属、ポリシリコン、バルクシリコン、誘電体等からなる重り部２６を別途形成し、重り部２６の表面をさらにパッシベーション膜２７によって覆ったものである。この実施例のようにセンサ可動部３に重り部２６を設けると、センサ可動部３が振動し易くなるので、小さな加速度に対するセンサ感度を向上させることができる。

【００５２】図４に示すものは本発明のさらに別な実施例による加速度センサＣを示す断面図である。この加速度センサＣにあっては、センサ可動部３の厚みを梁４の厚みよりも大きくしてセンサ可動部３の下面に一体にバルクシリコンの重り部２６を形成したものである。この実施例にあっても、重り部２６を形成したことにより、小さな加速度に対するセンサ感度を向上させることができる。

【００５３】図５に示すものは本発明のさらに別な実施例による加速度センサＤを示す断面図である。この加速

度センサDにあっては、センサ可動部3及びパッシベーション膜8，18に上下に貫通する1個もしくは複数個の開口部28を設けている。このようにセンサ可動部3に貫通する開口部28を設けることにより、センサ可動部3が変位するときの空気抵抗を軽減することができ、空気抵抗によるセンサ感度の低下を防止することができる。すなわち、センサ感度を向上させることができる。

【0054】図6に示すものは本発明のさらに別な実施例による加速度センサEを示す断面図である。この加速度センサEにあっては、センサ可動部3ないし凹部2の全体の上方をSiNからなる封止用膜29により覆って、センサ可動部3の位置している空間30を封止している。また、封止用膜29によってセンサ可動部3の変位が妨げられないよう、センサ可動部3の上面と封止用膜29との間にも空間30が形成されている。この加速度センサにあっては、センサ可動部3が封止用膜29によって封止されているので、センサ可動部3が外界と接触せず、汚染雰囲気中で使用した場合でも、センサ可動部3の汚染を防止することができる。

【0055】この封止用膜は次のようなシリコン加工プロセスを用いて形成することができる。すなわち、例えば図1のような構造の加速度センサを作製した後、センサ可動部3、梁4及びその周囲の領域を覆うようにしてPSG等のガラス材料からなる犠牲層（図示せず）を形成し、犠牲層の上にPECVD法によってSiNからなる封止用膜29を形成する。この後、封止用膜29を一部開口し、この開口から犠牲層をエッチングで除去することによって封止用膜29内に空間30を形成し、先にあけた封止用膜29の開口をPECVD法により堆積させたSiNで塞ぐ。

【0056】図7に示すものは本発明のさらに別な実施例による加速度センサFを示す断面図である。この加速度センサFにあっては、ポリシリコン又はSiNからなる封止用膜29によってセンサ可動部3の上方を覆い、封止用膜29によってセンサ可動部3を封止すると共にその封止空間31を減圧させたものである。この加速度センサFにあっては、センサ可動部3の汚染を防止できると共にセンサ可動部3の空気抵抗を低減することによってセンサ感度を向上させることができる。

【0057】この封止用膜29は、PSG等のガラス材料からなる犠牲層（図示せず）を形成した後、犠牲層の上にLPCVD法によってポリシリコン又はSiNからなる封止用膜29を形成し、封止用膜29を一部開口して犠牲層をエッチング除去することによって封止空間31を形成し、先にあけた封止用膜29の開口をLECVD法により堆積させたポリシリコン又はSiNで塞ぐ。開口を封止する際、加速度センサFはLP（低圧）CVD装置内にあるので、封止用膜29内の封止空間31が減圧される。

【0058】図8（a）（b）は本発明のさらに別な実施例による加速度センサGを示す一部破断した断面図及びピエゾ抵抗5を設けた梁4の一部を示す説明図である。この加速度センサGにあっては、ピエゾ抵抗5の形成されている領域をパッシベーション膜（誘電体膜）18の上から金属やドーピングされたポリシリコンなどの導電材料からなる導電層32を形成し、さらに、導電層32の上面をパッシベーション膜（誘電体膜）33によって覆っている。さらに、この導電層32は引き出しライン34の先端をパッシベーション膜18に開口したコントクトホール35からSi基板1に電気的に接合させてあり、導電層32をSi基板1と同電位（もしくは、接地電位）にしている。この加速度センサGにあっては、ピエゾ抵抗5の上に上下面をパッシーベーション膜33，18によって挟まれた導電層32が形成されているので、この導電層32によって電磁ノイズをシールドすることができ、外部からの電磁ノイズを受けにくくなって電磁ノイズに強くなる。

【0059】図9（a）（b）は本発明のさらに別な実施例による加速度センサHを示す一部破断した断面図及びピエゾ抵抗5を設けた梁4の一部を示す説明図である。この加速度センサHにあっては、ピエゾ抵抗5の上面に直接接触させるようにして熱良導体層36を形成している。ピエゾ抵抗5においては、各部に温度傾斜もしくは温度のバラツキがあると、抵抗出力に誤差が生じるので、全体に熱良導体層36を形成することによって、ピエゾ抵抗5内の温度傾斜ないし温度バラツキを小さくし、抵抗出力誤差を小さくできる。従って、加速度センサHの精度を向上させることができる。熱良導体層36としては、例えば導電率の小さな（すなわち、抵抗率の大きな）金属層を用いることができる。金属層を用いることによって高い熱伝導率を得ることができ、しかも、導電率の小さな金属層を用いることによってピエゾ抵抗5各部の電気的な短絡による抵抗出力誤差も防止することができる。

【0060】図10は本発明のさらに別な実施例による加速度センサJを示す断面図である。この加速度センサJにおいては、センサ可動部3の先端部分と対向する位置において、Si基板1から凹部2上方へ突出させるようにしてSi基板1上面にストッパ37を設けている。ストッパ37は、中央部に1個設けてもよく、あるいは、両側に2個設けても良く、あるいは3個以上設けてもよい。このようにSi基板1にストッパ37を設けていると、センサ可動部3が大きく変形した時、センサ可動部3がストッパ37に当ることによってそれ以上の変形を制限されるので、センサ可動部3の変形量が制限され、過大な変形によってセンサ可動部3ないし梁4が破損するのを防止することができる。

【0061】図11に示すものは本発明のさらに別な実施例による加速度センサの梁4の一部を拡大して示す図である。この実施例にあっては、梁4のピエゾ抵抗5が

設けられている部分の両側にV字状、円弧状などの切り欠き部（ノッチ）３８を設けたものである。このようにピエゾ抵抗５の近傍において梁４に切り欠き部３８を設けることにより、切り欠き部３８で梁４に応力集中を発生させることができる。このため切り欠き部３８の無いものと比較すると、同じ加速度の大きさに対して梁４の歪が大きくなり、加速度センサの感度が向上する。

【００６２】また、ピエゾ抵抗５の近傍において梁４に応力集中を発生させ、梁４の歪を大きくしてセンサ感度を向上させるためには、図１２に示すように、ピエゾ抵抗５の近傍において梁４に貫通孔３９や凹穴を設けてもよい。

【００６３】図１３に示すものは本発明のさらに別な実施例による加速度センサＫの一部を示す図である。この実施例においては、センサ可動部３を支持している梁４の表面にピエゾ抵抗５を形成してあり、ピエゾ抵抗５と共に抵抗値検出回路４０を構成するための抵抗４１をＳｉ基板１の表面に形成してある。従って、ピエゾ抵抗５はセンサ可動部３の変位によって梁４が歪むと、それに伴ってピエゾ抵抗５の抵抗値Ｒｐが変化するが、抵抗４１は梁４の歪によっては抵抗値Ｒの変化しない定数抵抗となっている。これらのピエゾ抵抗５及び抵抗４１は、Ｓｉ基板１上の配線パターンで図１４に示すようなブリッジ回路を構成される。このブリッジ回路からなる抵抗値検出回路４０では、入力端子４２，４３間に定電流Ｉが供給され、出力端子４４，４５間の電圧Ｖを検出することによりピエゾ抵抗５の抵抗値変化を検出できる。

【００６４】図１５は抵抗値検出回路の他例を示す図であって、梁４上に形成された４個のピエゾ抵抗５によってブリッジ回路を構成し、各ピエゾ抵抗５にそれぞれ温度補償用抵抗４６を直列に挿入している。この温度補償用抵抗４６は梁４の変形によって影響を受けないようにＳｉ基板１の表面に形成されている。しかも、温度補償用抵抗４６はピエゾ抵抗５と逆温度特性（つまり、温度変化係数の正負が逆）を有しており、ピエゾ抵抗５が梁４の歪によって抵抗変化を受けない場合には、温度が変化してもピエゾ抵抗５の抵抗値Ｒｐと温度補償用抵抗４６の抵抗値Ｒｃの和Ｒｐ＋Ｒｃはほぼ一定に保たれるようになっている。この抵抗値検出回路４７によれば、梁４の歪による抵抗値変化のみを検出することができ、温度変化の影響を受けにくくなる。

【００６５】図１６は抵抗値検出回路のさらに他例を示す図であって、４個のピエゾ抵抗５と感度調整用抵抗４８との直列体によってブリッジ回路を構成し、いずれか１箇所の分枝にオフセット調整用抵抗４９を挿入している。この感度調整用抵抗４８とオフセット調整用抵抗４９とは梁４の変形によって影響を受けないよう、Ｓｉ基板１の表面に形成されており、可変抵抗となっている。この抵抗値検出回路５０によれば、各感度調整用抵抗４８を調整することにより、抵抗値検出回路５０の感度を調整することができる。また、オフセット調整用抵抗４９を調整することにより、梁４の歪が０の場合に出力が０となるようオフセット量を調整することができる。

【００６６】図１７は本発明のさらに別な実施例による加速度センサＬを示す平面図である。この加速度センサＬにおいては、Ｓｉ基板１に複数のセンサ可動部３ａ～３ｅをアレイ状に配列し、各センサ可動部３を支持する梁４にピエゾ抵抗５を設けてある。各センサ可動部３ａ～３ｅは、異なる周波数の振動に対する感度を有している。例えば、各センサ可動部３ａ～３ｅは、図１８に示すＳ１～Ｓ５の感度曲線で表わされるような感度を有している。これらのセンサ可動部３ａ～３ｅに設けられたピエゾ抵抗５の出力は重畳して出力されており、この結果、加速度センサ全体の感度は、図１８に実線で示すように感度曲線の帯域が広くなる。

【００６７】なお、上記実施例においては、振動や衝撃を検出するための加速度センサの場合について説明したが、本発明のピエゾ抵抗変化検出方式センサは加速度以外の圧力や流速その他の物理量を検出するためのセンサとすることもできることはいうまでもない。

【００６８】図１９に示すものは本発明のさらに別な実施例によるモジュールＭである。すなわち、電気、電子部品等を一体化した集合部品や、回路基板等に電気、電子部品等を搭載した回路部品等のモジュールＭであって、この中には、パワーＩＣ等の発熱の大きなデバイス５１と共に本発明に係るピエゾ抵抗変化検出方式センサ５２が納められている。このように発熱の大きなデバイス５１と共にピエゾ抵抗変化検出方式センサ５２を一体モジュールとして構成する場合でも、本発明のピエゾ抵抗変化検出方式センサ５２を用いれば、約１５０℃以上の高温使用にも耐えるので、発熱の大きなデバイス５１から発散される熱によってピエゾ抵抗変化検出方式センサ５２が故障する恐れを小さくすることができ、モジュールＭの信頼性を高めることができる。

【００６９】図２０に示すものは本発明のさらに別な実施例による振動検出機能付き機器Ｎであって、本発明に係るピエゾ抵抗変化検出方式の加速度センサ５３を、原動機、電動機、発電機、ディスクブレーク、工作機等の機器５４に取り付けている。取り付け位置は、機器５４の種類に応じて適当な位置を選択されるが、例えば、原動機や電動機の外部や内部に直接に取り付けたり、発電機の外部に直接取り付けたり、ディスクブレークのパッド付近や工作機の刃先近傍などに取り付けると良い。本発明の加速度センサ５３をこれらの機器に用いることにより、これらの機器の振動を感度よく検出することができ、異常振動が発生した場合には、直ちに検出することができる。しかも、使用限界温度が高いので、これらの機器５４の熱によっても加速度センサ５３が故障しにくく、これらの機器５４の信頼性も向上する。

【００７０】図２１に示すものは本発明のさらに別な実

施例によるボイラ圧検出装置Pを示す概略図であって、本発明に係るピエゾ抵抗変化検出方式の圧力センサ５５（例えば、圧力の変化によって変位するダイアフラムの歪を検出するもの）をボイラ５６に取り付けている。圧力センサ５５はボイラ５６内部の蒸気に触れており、あるいは、圧力センサ５５へボイラ５６内部の蒸気が導かれており、圧力センサ５５によってボイラ蒸気圧を直接計測できるようにしている。本発明の圧力センサ５５は１５０℃以上の高温にも耐えるので、ボイラ５６のような用途にも用いることができる。又、センサとしては、圧力センサ５５でなく、加速度センサをボイラ５６に直接取り付け、ボイラ５６の異常振動等を検出するようにしてもよい。

【００７１】図２２に示すものは本発明のさらに別な実施例であって、高温気体用の物理量検出装置Qを示す図である。この実施例においては、蒸気等の高温気体の通過する管５７の外側にピエゾ抵抗変化検出方式センサ５２を取り付け、ピエゾ抵抗変化検出方式センサ５２を管５７内の高温気体に接触させている。あるいは、ピエゾ抵抗変化検出方式センサ５２を管５７内に直接取り付けてもよい。そして、このピエゾ抵抗変化検出方式センサ５２により、高温気体の圧力や流速、温度等の物理量を検出することができる。この場合も本発明のピエゾ抵抗変化検出方式センサ５２を用いることにより、１５０℃以上の高温気体の物理量の検出を感度良く行なうことが可能になる。又、物理量測定のために高温気体をバイパスさせるサイドダクトを用いることなく、直接測定が可能になるので、測定誤差を小さくすることができる。

【００７２】図２３に示すものは本発明のさらに別な実施例による異常状態検出装置Rを示す概略図である。この実施例においては、原動機、電動機、発電機、工作機、ディスクブレーキ等の機器５４にピエゾ抵抗変化検出方式センサ５２を取り付け、ピエゾ抵抗変化検出方式センサ５２の出力を増幅器５８で増幅した後、信号処理部５９へ入力している。信号処理部５９は、ピエゾ抵抗変化検出方式センサ５２の検出信号にファジイ処理を施すことによって信号処理及び判断を行なっており、機器５４の異常の有無を監視し、機器５４に異常が発生していると判断すると、機器５４へ制御信号を出力して異常が納まるように機器５４をフィードバック制御する。あるいは、信号処理部５９から外部へ異常を知らせる警報ないし警告を出力する。

【００７３】この異常状態検出装置Rを具体的に説明すると、例えば機器５４が原動機の場合であると、ピエゾ抵抗変化検出方式センサ５２（例えば、加速度センサ）は原動機のノッキングを検出する。ピエゾ抵抗変化検出方式センサ５２がノッキングを検出すると、信号処理部はこの検出信号に対してファジイ処理を行ない、点火時期変更等のフィードバック信号を出力することによってノッキング状態を回避する。

【００７４】あるいは、機器５４がディーゼル式の原動機の場合には、ピエゾ抵抗変化検出方式センサ５２によって機器５４のスクラップ音を検出し、信号処理部はこの検出信号に対してファジイ処理を行ない、過度のスクラップ音を検出した場合には、信号処理部５９から原動機へ制御信号を出力してスクラッピングを抑制するように原動機をフィードバック制御する。

【００７５】また、機器５４がディスクブレーキの場合には、ピエゾ抵抗変化検出方式センサ５２によってディスクブレーキの振動を検出し、この検出信号にファジイ処理を施すことによってディスクあるいはブレーキパッドの摩耗を検出し、警告信号を出力するようにできる。

【００７６】また、機器５４が工作機の場合には、その刃先近傍に取り付けられたピエゾ抵抗変化検出方式センサ５２によって振動等を検出し、信号処理部５９はその検出信号にファジイ処理を施すことにより刃先の欠損、摩耗等による異常振動を検出し、工作機へ制御信号を出力して工具交換を自動で行なわせる。あるいは、警告を出力するようにしてもよい。

【００７７】また、機器５４がボイラの場合は、ボイラに取り付けられたピエゾ抵抗変化検出方式センサ５２からの検出信号を信号処理部５９でファジイ処理することにより、ボイラ内の異常燃焼を検知することができる。そして、異常燃焼を検知すると、適正燃焼量となるようにボイラへ制御信号を出力し、あるいは、警告を出力することができる。

【００７８】また、機器５４が高温気体の流れる管を有する機器５４である場合には、管に取り付けられたピエゾ抵抗変化検出方式センサ５２からの検出信号を信号処理部５９でファジイ処理し、管内の高温気体の流量や圧力が適正値から外れていないか監視する。そして、適正値から外れているのを検知すると、目標値となるように機器５４へ制御信号を出力する。

【００７９】

【発明の効果】本発明によれば、バルクシリコンからなるピエゾ抵抗と基板とを酸化膜によって誘電分離しているので、約１５０℃以上の高温でもピエゾ抵抗と基板との間にリーク電流が流れることがなく、高温環境下での使用が可能になる。しかも、多孔質シリコンを熱酸化させた絶縁膜によって誘電分離しているので、製造工程においてピエゾ抵抗のゲージ率が低下することがない。この結果、バルクシリコン抵抗の利点である、感度及び分解能が高く、検出範囲が広いという長所を生かすことができる。この結果、①１５０℃以上の高温使用が可能で、かつ、②高感度、高分解能で、広い検出範囲と良好な温度特性を有するピエゾ抵抗変化検出方式センサを実現することができる。

【００８０】また、２枚の基板を必要とせず、１枚の基板から作製することができるので、コストも安価にすることができる。

【0081】加えて、以下のセンサにはそれぞれ次のような利点がある。このピエゾ抵抗変化検出方式センサにおいて、センサ可動部に重り部を形成すれば、低入力レベルの検出物理量に対する感度を向上させることができる。

【0082】さらに、センサ可動部に１個もしくは複数個の開口部を設ければ、センサ可動部の変形時における空気抵抗を軽減することにより、センサ感度を向上させることができる。

【0083】また、前記センサ可動部を封止すれば、センサ可動部を汚染雰囲気と遮断することができ、耐環境性が向上する。その場合、封止内部を減圧しておけば、空気抵抗が減少してセンサ感度が向上する。

【0084】また、ピエゾ抵抗の上面に導電層を形成し、この導電層を基板と同電位にしておけば、電磁ノイズを受けにくくなり、ピエゾ抵抗変化検出方式センサのS／N比が向上する。

【0085】あるいは、ピエゾ抵抗の上に熱良導体層を直接に形成しておけば、ピエゾ抵抗内の温度傾斜が小さくなるため、ピエゾ抵抗からの抵抗出力誤差を小さくすることができる。

【0086】また、基板にセンサ可動部の変形を制限するためのストッパを設けておけば、センサ可動部の過大変位による破損を防止することができる。

【0087】さらに、センサ可動部を弾性支持する支持部に切り欠き部もしくは開口部を設ければ、切り欠き部もしくは開口部に応力集中が発生し、その結果同一入力に対する支持部の歪が大きくなってセンサ感度が向上する。

【0088】また、基板上にピエゾ抵抗の抵抗値を検出するための抵抗値検出回路を設ければ、別途抵抗値検出回路を必要とせず、抵抗値検出回路も含めたピエゾ抵抗変化検出方式センサをコンパクトにまとめることができる。さらに、その抵抗値検出回路内にピエゾ抵抗と逆温度特性の温度補償用抵抗を含ませておけば、温度変化に伴うピエゾ抵抗の出力変化と温度補償用抵抗の出力変化を互いに相殺させることができ、温度変化による検出誤差を小さくすることができる。あるいは、抵抗値検出回路にオフセット抵抗ないし感度調整用抵抗を設けておけば、抵抗値検出回路のオフセット値や検出感度を調整することができる。

【0089】また、同一基板に複数のセンサ可動部及び複数のピエゾ抵抗を設け、各センサ可動部の感度領域を少しずつ異ならせておけば、各センサ可動部の感度を重畳させることによって感度領域を広帯域化することができる。

【0090】また、本発明のピエゾ抵抗変化検出方式センサは上記のような長所を有しているので、パワーＩＣのような発熱部品を含むモジュール、ボイラ、高温気体の流れる管内などの高温環境下においても用いることができ、このような高温環境下でも高感度の検出を行なうことができる。

【0091】また、原動機、電動機、発電機、ディスクブレーキ、工作機等の機器に取り付けることによって、高感度で振動の検出を行なうことができ、さらに、この検出信号を信号処理部でファジイ処理を行なうことにより異常を検出するようにすれば、高感度で高温環境下でも使用可能な異常検出装置を得ることができる。

【図面の簡単な説明】

【図１】本発明の一実施例によるピエゾ抵抗変化検出方式の加速度センサを示す斜視図である。

【図２】（ａ）（ｂ）（ｃ）（ｄ）（ｅ）（ｆ）（ｇ）（ｈ）（ｉ）は同上の加速度センサの製造方法を示す断面図である。

【図３】本発明の別な実施例による加速度センサを示す断面図である。

【図４】本発明のさらに別な実施例による加速度センサを示す断面図である。

【図５】本発明のさらに別な実施例による加速度センサを示す断面図である。

【図６】本発明のさらに別な実施例による加速度センサを示す断面図である。

【図７】本発明のさらに別な実施例による加速度センサを示す断面図である。

【図８】（ａ）は本発明のさらに別な実施例による加速度センサを示す一部破断した断面図、（ｂ）はその梁の一部を示す説明図である。

【図９】（ａ）は本発明のさらに別な実施例による加速度センサを示す一部破断した断面図、（ｂ）はその梁の一部を示す説明図である。

【図１０】本発明のさらに別な実施例による加速度センサを示す断面図である。

【図１１】本発明のさらに別な実施例による加速度センサの梁の一部を示す平面図である。

【図１２】本発明のさらに別な実施例による加速度センサの梁の一部を示す平面図である。

【図１３】本発明のさらに別な実施例による加速度センサであって、抵抗値検出回路を構成するピエゾ抵抗及び定数抵抗を示す平面図である。

【図１４】同上の抵抗値検出回路を示す回路図である。

【図１５】抵抗値検出回路の他例を示す回路図である。

【図１６】抵抗値検出回路のさらに他例を示す回路図である。

【図１７】本発明のさらに別な実施例による加速度センサを示す平面図である。

【図１８】同上の作用説明図である。

【図１９】本発明のさらに別な実施例を示す概略図である。

【図２０】本発明のさらに別な実施例を示す概略図である。

【図２１】本発明のさらに別な実施例を示す概略図である。

【図２２】本発明のさらに別な実施例を示す概略図である。

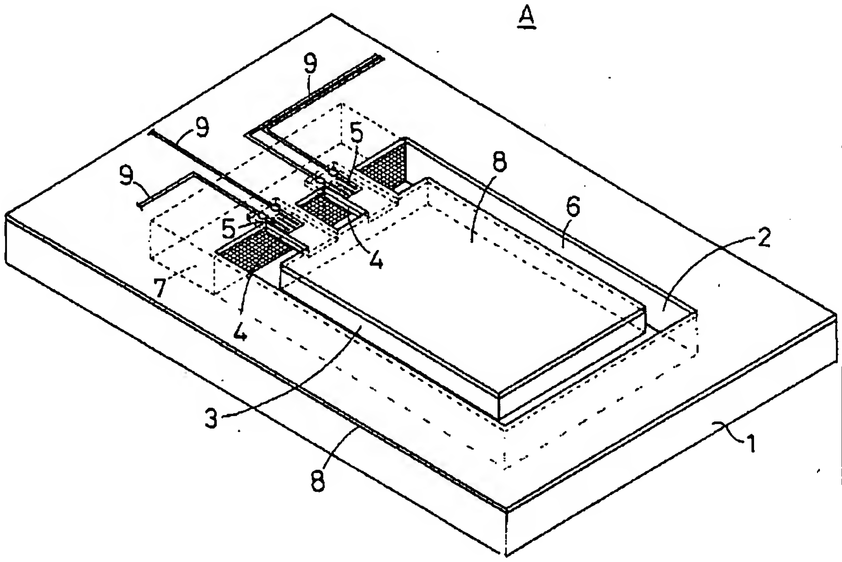
【図２３】本発明のさらに別な実施例を示す概略図である。

【図２４】（ａ）（ｂ）（ｃ）（ｄ）（ｅ）（ｆ）（ｇ）（ｈ）は従来例による加速度センサの製造方法を示す断面図である。

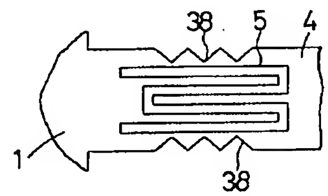
【符号の説明】

１　Ｓｉ基板
３　センサ可動部
４　梁
５　ピエゾ抵抗
６　誘電分離層（空間）
７　誘電分離層（酸化膜）
１６Ａ　多孔質Ｓｉ領域
１６Ｂ　SiO_2領域
１７Ａ　高密度多孔質Ｓｉ領域
１７Ｂ　高密度SiO_2領域
２６　重り部
２８　開口部
２９　封止用膜
３２　導電層
３６　熱良導体層
３７　ストッパ
３８　切り欠き部
３９　貫通孔

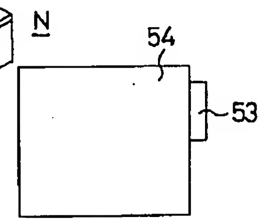
【図１】



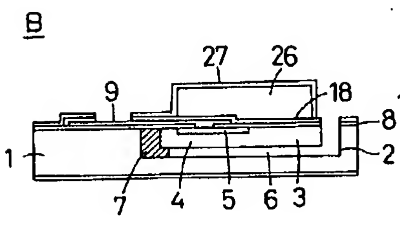
【図１１】



【図２０】



【図３】



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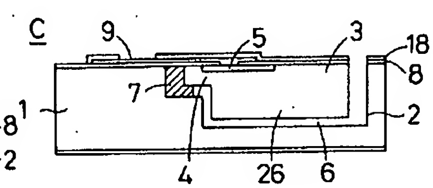
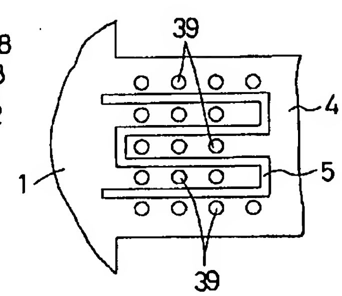


【図１２】



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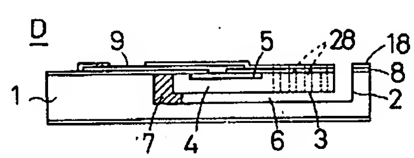

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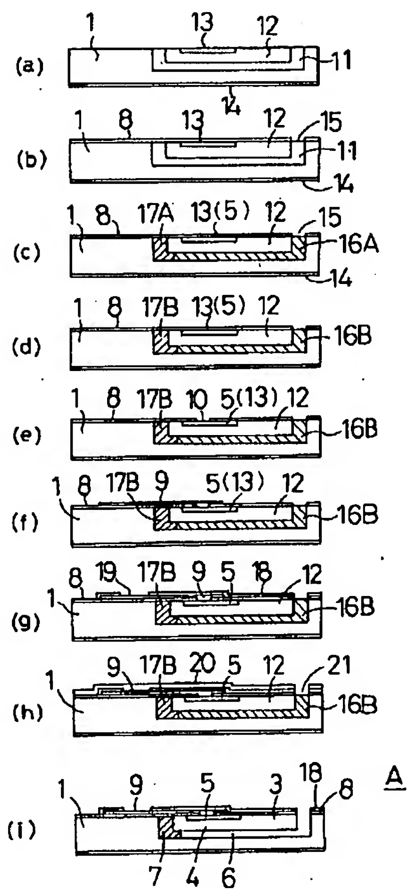

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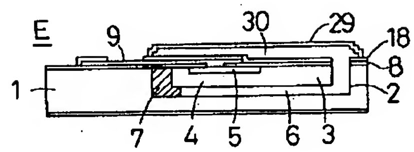

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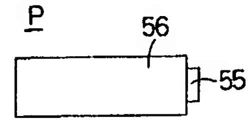

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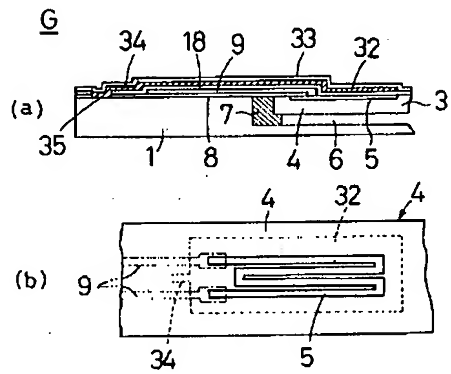

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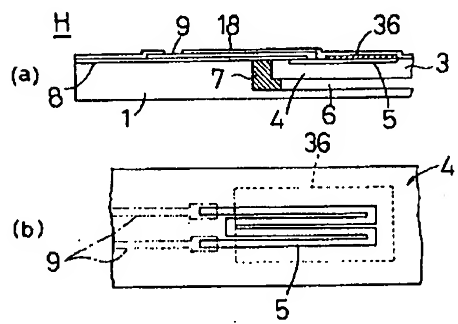

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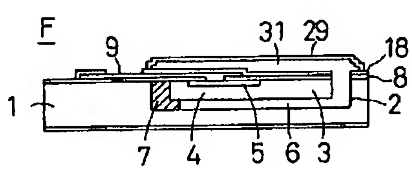

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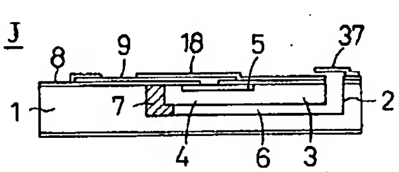

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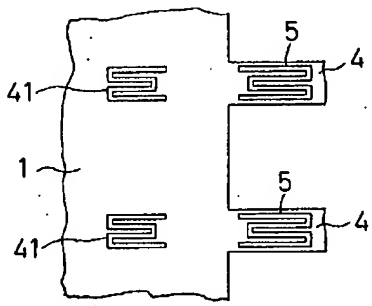

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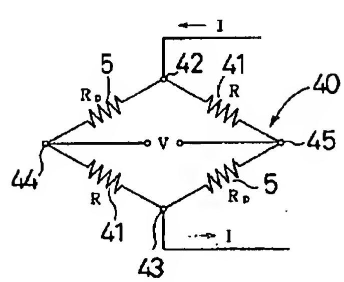

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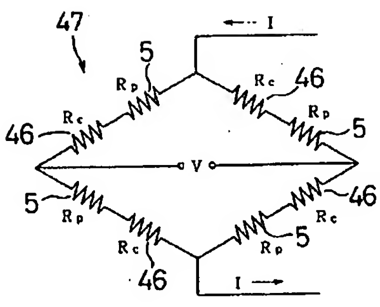

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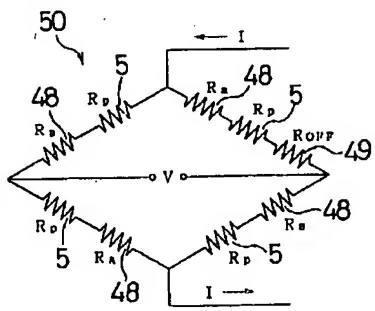

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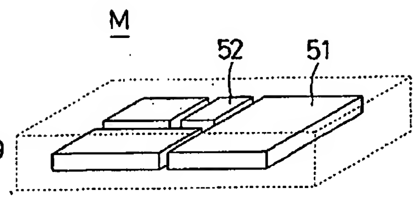
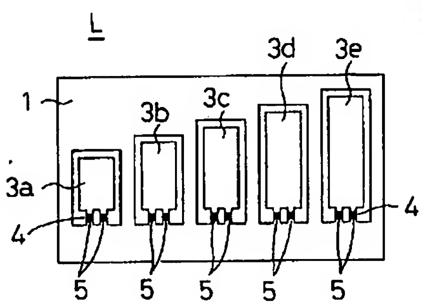


【図17】



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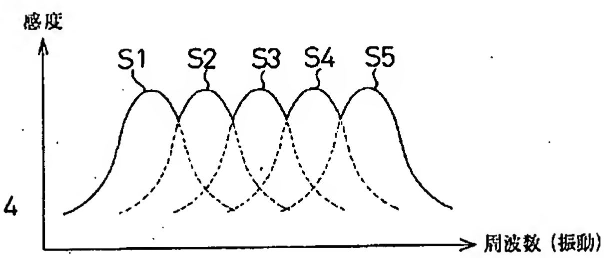

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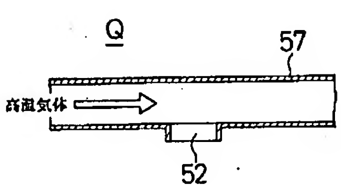

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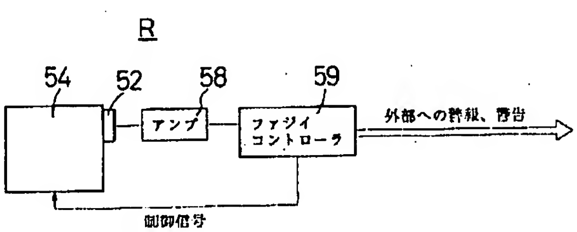

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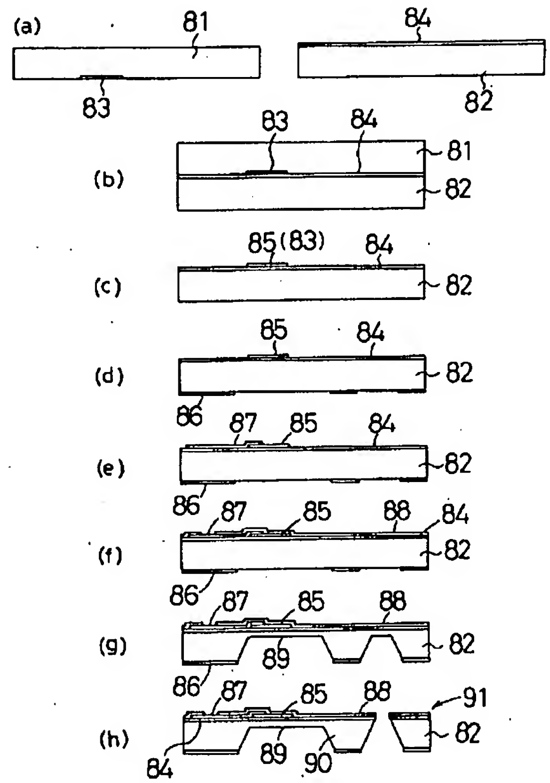
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JP 06-324,074

CLAIMS

[Claim(s)]
[Claim 1] The piezoresistance change detection method sensor characterized by carrying out dielectric separation with the oxide film which was made to oxidize porosity silicon thermally and formed said piezoresistance which consists of bulk silicon, and said substrate in the piezoresistance change detection method sensor which detects the variation rate of sensor moving part supported by the substrate by the piezoresistance.
[Claim 2] The piezoresistance change detection method sensor according to claim 1 characterized by forming the weight section in said sensor moving part.
[Claim 3] The piezoresistance change detection method sensor according to claim 1 or 2 characterized by preparing said sensor moving part one piece or two or more openings.
[Claim 4] The piezoresistance change detection method sensor according to claim 1, 2, or 3 characterized by closing said sensor moving part.
[Claim 5] The piezoresistance change detection method sensor according to claim 4 characterized by decompressing said interior of closure.
[Claim 6] The piezoresistance change detection method sensor according to claim 1, 2, 3, 4, or 5 characterized by having formed the conductive layer which consists of electrical conducting materials, such as a metal and doped polish recon, on both sides of a dielectric film in the top face of said piezoresistance, and making this conductive layer into a substrate and same electric potential.
[Claim 7] The piezoresistance change detection method sensor according to claim 1, 2, 3, 4, 5, or 6 characterized by forming directly a thermal conductor layer with good thermal conductivity on said piezoresistance.
[Claim 8] The piezoresistance change detection method sensor according to claim 1, 2, 3, 4, 5, 6, or 7 characterized by forming the stopper for restricting deformation of sensor moving part to said substrate.
[Claim 9] The piezoresistance change detection method sensor according to claim 1, 2, 3, 4, 5, 6, 7, or 8 characterized by having prepared said piezoresistance in the supporter which carries out elastic support of said sensor moving part, and preparing the notching section or opening in said supporter [near the piezoresistance].
[Claim 10] 1, 2, 3, 4, 5, 6, 7 and 8 which are characterized by preparing a resistance detector on the supporter which carries out elastic support of said sensor moving part, and said substrate, or a piezoresistance change detection method sensor given in 9.
[Claim 11] The piezoresistance change detection method sensor according to claim 10 characterized by making it make the property change by temperature compensate by preparing said piezoresistance and resistance of the reverse temperature characteristic on said substrate, and constituting said a part of resistance detector from this resistance.
[Claim 12] The piezoresistance change detection method sensor according to claim 10 characterized by having prepared offset resistance thru/or the resistance for sensitivity settling on said substrate, and constituting said a part of resistance detector from this offset resistance thru/or resistance for sensitivity settling.

[Claim 13] 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 which are characterized by preparing two or more sensor moving part and two or more piezoresistances in said substrate, or a piezoresistance change detection method sensor given in 12.
[Claim 14] The module characterized by combining exoergic components like Power IC, claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12, or a piezoresistance change detection method sensor given in 13.
[Claim 15] The device with an oscillating detection function characterized by attaching claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 or a piezoresistance change detection method sensor given in 13 in devices, such as a prime mover, a motor, a generator, a disk brake, and a machining machine.
[Claim 16] Physical quantity detection equipment of the boiler characterized by making it make a boiler detect physical quantity, such as vibration of direct installation and a boiler and a pressure, for claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 or a piezoresistance change detection method sensor given in 13.
[Claim 17] Physical quantity detection equipment for gases characterized by attaching in tubing with which elevated-temperature gases, such as a steam, pass claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 or a piezoresistance change detection method sensor given in 13, and making it make physical quantity, such as a pressure of an elevated-temperature gas, and the rate of flow, detect.
[Claim 18] Abnormal-condition detection equipment characterized by having a signal-processing means to detect abnormalities by performing fuzzy processing to claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 or 13 to the detecting signal of the piezoresistance change detection method sensor of a publication, and said sensor.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to a piezoresistance change detection method sensor. It is related with the piezoresistance change detection method sensor applied as various sensors for detecting physical quantity, such as force, a pressure, acceleration, the rate of flow, and a tilt angle, especially. Furthermore, it is related with the module equipped with the piezoresistance change detection method sensor, a device with an oscillating detection function, the physical quantity detection equipment of a boiler, the physical quantity detection equipment for gases, and abnormal-condition detection equipment.
[0002]
[Description of the Prior Art] It is divided roughly into what used polish recon for electrical resistance materials, and the thing which used bulk silicon when the conventional piezoresistance change detection method sensor is seen from the point of the quality of the material of a piezoresistance.
[0003] (Piezoresistance change detection method sensor which used polish recon) If it is in the piezoresistance change detection method sensor which used polish recon as the quality of the material of a piezoresistance, since it is easy to form a detached core between a piezoresistance and a silicon substrate, and to carry out dielectric separation on the manufacture process, the piezoresistance by which dielectric separation was carried out with the silicon substrate is used. Therefore, by the sensor concerned, unless dielectric breakdown of a detached core occurs, between a silicon substrate and a piezoresistance, there is no possibility that a current may flow and even an elevated temperature 150 degrees C or more can be used. That is, it has the advantage in which the service temperature limitation by the side of an elevated temperature is high.
[0004] However, the piezoresistance (henceforth polish recon resistance) using polish recon has a small gage factor (resistance change to the amount of distortion comparatively) as compared with the piezoresistance (henceforth bulk silicon resistance) which used bulk silicon, and only about 1/5 resistance change of bulk silicon resistance usually breaks out to the same amount of distortion. For this reason, when the same configuration and the piezoresistance change detection method sensor of a configuration were manufactured, sensibility and resolving power were inferior to the piezoresistance change detection method sensor which used bulk silicon resistance in the piezoresistance change detection method sensor using polish recon resistance.
[0005] Moreover, since the destructive distortion of polish recon resistance was smaller than bulk silicon resistance, when the maximum distortion at the time of detection would be designed low and having been doubled with the lowness of detection sensitivity, there was a fault that the detection range of input physical quantity, such as a pressure and acceleration, will become narrow.
[0006] Furthermore, as compared with bulk silicon resistance, polish recon resistance is one with a large (usually about 5 times of bulk silicon resistance) temperature coefficient of resistance (TCR), and its change in resistance by temperature is large. For this reason, the piezoresistance change detection method sensor using polish recon resistance had the bad temperature characteristic, and it was unstable

to the temperature change.
[0007] (Piezoresistance change detection method sensor which used bulk silicon) By the piezoresistance change detection method sensor which used bulk silicon, since sensibility and resolution are high since the gage factor of bulk silicon resistance is large as mentioned above as compared with polish recon resistance, and destructive distortion is also large, there is the advantage in which the detection range can be made large. Furthermore, since the temperature coefficient of resistance of bulk silicon resistance is small, the temperature characteristic is also good.
[0008] however, by the piezoresistance change detection method sensor using bulk silicon resistance Are performing separation with bulk silicon resistance and a silicon substrate by p-n junction, and moreover, since the p mold of the property of piezoresistances, such as a gage factor, is better and it is common to maintain n layers of a silicon substrate to high potential Leakage current tended to flow on both sides of the detached core of p-n junction, and there was a fault with the as low service temperature limitation by the side of an elevated temperature as about 150 degrees C under hot environments (150 degrees C or more).
[0009] For this reason, a piezoresistance change detection method sensor which are ** high sensitivity and a high resolution, and fills to coincidence two demands that the detection range has a high service temperature limitation in ** elevated-temperature side with the goodness of the property of being large is desired.
[0010] Then, in order to satisfy these two demands to coincidence, the manufacture approach as shown in drawing 24 is proposed. This manufacture approach is explained according to drawing 24 . It is two Si substrates (silicon wafer) 81 and 82 which are shown in drawing 24 (a), and by driving p mold ion, such as boron, into the inferior surface of tongue of one Si substrate 81, the p++ layer 83 used as a piezoresistance 85 is formed, and the oxide film (SiO2 film) 84 is formed in the top face of the Si substrate 82 of another side. After joining the Si substrate 81 of each other in piles on this Si substrate 82 (drawing 24 (b)) and joining, etching removal of the upper Si substrate 81 is carried out using alkali etchant, such as KOH. At this time, as the p++ layer 83 remains on the Si substrate 82, without being etched since the etching rate is smaller than the Si substrate 81 and it is shown in drawing 24 (c), a piezoresistance 85 is formed on an oxide film 84.
[0011] Then, an SiN film is formed in the inferior surface of tongue of the Si substrate 82 with a low voltage CVD method, and the mask 86 for anisotropic etching is formed by carrying out patterning of the SiN film (drawing 24 (d)). Moreover, a piezoresistance 85 is made to flow in the top face of the Si substrate 82, metal wiring 87 is given to it (drawing 24 (e)), and the passivation film 88 is further formed in it with glass ingredients, such as PSG, (drawing 24 (f)). Subsequently, the part exposed from the mask 86 is deleted to the thickness of a beam 89 by performing anisotropic etching to the Si substrate 82 from an inferior-surface-of-tongue side (drawing 24 (g)). Furthermore, a beam 89 and the sensor moving part 90 are formed by leaving the part used as a beam 89 and carrying out opening of other parts for a thin-walled part by etching (drawing 24 (h)).
[0012]
[Problem(s) to be Solved by the Invention] If it is in the acceleration sensor 91 manufactured as mentioned above, the piezoresistance 85 which separates with an oxide film 84 and consists of bulk silicon is formed in the top face of a beam 89. Therefore, it insulates with the oxide film 84, and a piezoresistance 85 and the Si substrate 82 do not have a fear of leakage current flowing between a piezoresistance 85 and the Si substrate 82, and become usable also in an elevated temperature 150 degrees C or more.
[0013] However, in order to make it only a piezoresistance 85 remain by predetermined thickness like drawing 24 (c) when etching the upper Si substrate 81 after joining two Si substrates 81 and 82, without a piezoresistance 85 being etched by alkali etchant, it is necessary to enlarge the ion injection rate to the p++ layer 83 (piezoresistance 85). However, when carried out that the ion injection rate to the p++ layer 83 is enlarged, and it is hard to be etched, a gage factor was not able to be made not much high. Therefore, the advantage of bulk silicon resistance that the detection range is wide was not able to be efficiently employed by high sensitivity and the high resolution.

[0014] Moreover, in order to obtain one acceleration sensor 91, two Si substrates 81 and 82 were needed, and there was a fault that the process which joins two Si substrates 81 and 82, and the process which carries out web thinning until it becomes the thickness for about one sheet about the joined Si substrates 81 and 82 were needed, the yield of a product was bad, and cost cost dearly, further.
[0015] Therefore, it is ** high sensitivity and a high resolution, and two demands that the detection range had a high service temperature limitation in ** elevated-temperature side with the goodness of the property of being large were not able to be filled with the conventional piezoresistance change detection method sensor to coincidence.
[0016] The place which this invention is made in view of the fault of the above-stated conventional example, and is made into the purpose is by carrying out dielectric separation of the piezoresistance and sensor moving part which consist of bulk silicon with a substrate with an oxide film to offer the piezoresistance change detection method sensor which fills two demands, the above-mentioned ** and **, to coincidence.
[0017]
[Means for Solving the Problem] The piezoresistance change detection method sensor of this invention is characterized by carrying out dielectric separation with the oxide film which was made to oxidize porosity silicon thermally and formed said piezoresistance which consists of bulk silicon, and said substrate.
[0018] Moreover, the weight section may be formed in said sensor moving part in the above-mentioned piezoresistance change detection method sensor. Or one piece or two or more openings may be prepared for said sensor moving part. Furthermore, said sensor moving part may be closed. In that case, the interior of closure may be decompressed.
[0019] Moreover, in the above-mentioned piezoresistance change detection method sensor, the conductive layer which consists of electrical conducting materials, such as a metal and doped polish recon, on both sides of a dielectric film may be formed in the top face of said piezoresistance, and this conductive layer may be made into a substrate and same electric potential. Or a thermal conductor layer with good thermal conductivity may be directly formed on said piezoresistance.
[0020] Moreover, in the above-mentioned piezoresistance change detection method sensor, the stopper for restricting deformation of sensor moving part to said substrate may be formed. Furthermore, said piezoresistance may be prepared in the supporter which carries out elastic support of said sensor moving part, and the notching section or opening may be prepared in said supporter [near the piezoresistance].
[0021] Moreover, a resistance detector can be established in the above-mentioned piezoresistance change detection method sensor. In that case, said piezoresistance and resistance of the reverse temperature characteristic are prepared on said substrate, and you may make it make the property change by temperature compensate by constituting said a part of resistance detector from this resistance. Or offset resistance thru/or the resistance for sensitivity settling may be prepared on said substrate, and said a part of resistance detector may consist of this offset resistance thru/or resistance for sensitivity settling.

[0022] Furthermore, two or more sensor moving part and two or more piezoresistances may be prepared in said substrate.
[0023] Moreover, the module of this invention is characterized by combining exoergic components like Power IC, and the above-mentioned piezoresistance change detection method sensor.
[0024] Moreover, the device with an oscillating detection function of this invention is characterized by attaching the above-mentioned piezoresistance change detection method sensor in devices, such as a prime mover, a motor, a generator, a disk brake, and a machining machine.
[0025] Moreover, the physical quantity detection equipment of the boiler of this invention is characterized by making it make a boiler detect physical quantity, such as vibration of direct installation and a boiler and a pressure, for the above-mentioned piezoresistance change detection method sensor.
[0026] Moreover, the physical quantity detection equipment for gases of this invention is attached in tubing with which elevated-temperature gases, such as a steam, pass the above-mentioned piezoresistance change detection method sensor, and is characterized by making it make physical

quantity, such as a pressure of an elevated-temperature gas, and the rate of flow, detect.
[0027] Moreover, the abnormal-condition detection equipment of this invention is characterized by having a signal-processing means to detect abnormalities by performing fuzzy processing to the detecting signal of the above-mentioned piezoresistance change detection method sensor and said sensor.
[0028]
[Function] If it is in the piezoresistance change detection method sensor of this invention, since dielectric separation of the piezoresistance and substrate which consist of bulk silicon is carried out with the oxide film, leakage current does not flow between a piezoresistance and a substrate and the use under hot environments is attained by even elevated temperature about 150 degrees C or more. Moreover, if it is in this invention, since the insulator layer for dielectric separation is formed by making porosity silicon oxidize thermally, after embedding a piezoresistance at sensor moving part thru/or its supporting section, the field of the perimeter is formed into porosity silicon, by oxidizing thermally further, an oxide film can be formed and dielectric separation of a piezoresistance and the substrate can be carried out. Therefore, using two substrates, a piezoresistance is piled up with the substrate of another side on the oxide film of one substrate, and the gage factor of a piezoresistance does not fall in a production process like the conventional example which forms a piezoresistance on an oxide film with web thinning. Consequently, the sensibility and resolution which are the advantage of bulk silicon resistance are high, and the advantage in which the detection range is wide can be employed efficiently. Consequently, the detection range large at ** high sensitivity and a high resolution in which the elevated-temperature use beyond **150 degree C is possible, and the piezoresistance change detection method sensor which has the good temperature characteristic are realizable.
[0029] Moreover, since two substrates are not needed like the conventional piezoresistance change detection method sensor shown in drawing 24 but it can produce from one substrate, cost can also be made cheap.
[0030] Moreover, in this piezoresistance change detection method sensor, if the weight section is formed in sensor moving part, the sensibility to the detection physical quantity of a low input level can be raised.
[0031] Furthermore, if one piece or two or more openings are prepared for sensor moving part, sensor sensibility can be raised by mitigating the air resistance at the time of deformation of sensor moving part.
[0032] Moreover, if said sensor moving part is closed, sensor moving part can be intercepted with a contamination ambient atmosphere, and a resistance to environment will improve. In that case, if the interior of closure is decompressed, air resistance will decrease and sensor sensibility will improve.
[0033] moreover -- if a conductive layer is formed in the top face of a piezoresistance and this conductive layer is made into a substrate and same electric potential -- electromagnetism -- a noise -- winning popularity -- being hard -- the S/N ratio of a piezoresistance change detection method sensor improves.
[0034] Or if the thermal conductor layer is directly formed on the piezoresistance, since the temperature inclination in a piezoresistance will become small, the resistance output error from a piezoresistance can be made small.
[0035] Moreover, if the stopper for restricting deformation of sensor moving part to a substrate is formed, breakage by the fault serious grade of sensor moving part can be prevented.
[0036] Furthermore, if the notching section or opening is prepared in the supporter which carries out elastic support of the sensor moving part, stress concentration will occur in the notching section or opening, as a result, the distortion of a supporter to the same input will become large, and sensor sensibility will improve.
[0037] Moreover, if the resistance detector for detecting the resistance of a piezoresistance is prepared on a substrate, a resistance detector is not needed separately but a piezoresistance change detection method sensor also including a resistance detector can be packed into a compact. Furthermore, if a piezoresistance and the resistance for temperature compensation of the reverse temperature

characteristic are included in the resistance detector, the output change of a piezoresistance and the output change of the resistance for temperature compensation accompanying a temperature change can be made to be able to offset mutually, and the detection error by the temperature change can be made small. Or if offset resistance thru/or the resistance for sensitivity settling are prepared in the resistance detector, the offset value and detection sensitivity of a resistance detector can be adjusted.
[0038] Moreover, if two or more sensor moving part and two or more piezoresistances are prepared in the same substrate and the sensibility field of each sensor moving part is changed little by little, a sensibility field can be broadband-ized by making the sensibility of each sensor moving part superimpose.
[0039] Moreover, since the piezoresistance change detection method sensor of this invention has the above advantages, it can be used for the bottom of the hot environments in the module containing exoergic components like Power IC, a boiler, and tubing with which an elevated-temperature gas flows etc., and can detect high sensitivity also under such hot environments.
[0040] Moreover, vibration is detectable by high sensitivity by attaching in devices, such as a prime mover, a motor, a generator, a disk brake, and a machining machine, and further, if abnormalities are detected by performing fuzzy processing for this detecting signal in the signal-processing section, malfunction detection equipment usable also under hot environments can be obtained by high sensitivity.
[0041]
[Example] Drawing 1 is the perspective view showing acceleration-sensor A of the piezoresistance change detection method by one example of this invention fractured in part. 1 is a p-Si substrate and the rectangle-like crevice 2 is cut in the top face of the Si substrate 1. n -- The sensor moving part 3 which consists of bulk Si is dedicated in the crevice 2 in the condition of having floated in the air, and is supported by the Si substrate 1 by two level beams 4. Therefore, if the sensor moving part 3 senses and displaces acceleration, vibration, an impact, etc., a beam 4 will carry out elastic deformation. The piezoresistance 5 which consists of p+-bulk Si is formed in the surface of a beam 4, and the deformation amount of a beam 4 is detected as resistance change of a piezoresistance 5. Therefore, the acceleration which joins the sensor moving part 3 by the change in resistance of a piezoresistance 5, vibration, an impact, etc. are detected.
[0042] Moreover, dielectric separation of the sensor moving part 3, a beam 4, and a piezoresistance 5 and the Si substrate 1 is carried out by the dielectric detached core. That is, the dielectric detached core 6 which consists of air (dielectric) is formed in the space between the sensor moving part 3 and a beam 4, and the Si substrate 1 (crevice 2 inside). Furthermore, the dielectric detached core 7 which the field which is supporting the beam 4 of the edge of a crevice 2 becomes from the silicon oxide (SiO2) film is formed. Therefore, the sensor moving part 3 has structure which had the end face section of a beam 4 supported by the dielectric detached core 7 embedded in the Si substrate 1, dielectric separation of the sensor moving part 3 and the beam 4 is completely carried out from the Si substrate 1, and even an elevated temperature 150 degrees C or more does not have a possibility that leakage current may flow between a piezoresistance 5 and the Si substrate 1.
[0043] Furthermore, the Si substrate 1, the sensor moving part 3, the beam 4, and the front face of a piezoresistance 5 are covered with the passivation film 8 which consists of silicon nitride (SiN), and the metal wiring 9 of aluminum formed on the passivation film 8 is electrically connected to the passivation film 8 to the both ends of a piezoresistance 5 through the contact hole 10 which carried out opening. In addition, the passivation film which consists of SiN further may be formed on this.
[0044] Below, the manufacture approach of the above-mentioned acceleration-sensor A is explained. The manufacture approach of this acceleration-sensor A (the structure of metal wiring differs from the acceleration sensor of drawing 1 a little.) is shown in drawing 2 (a) - (i), and the manufacture approach concerned is explained according to drawing 2 (a) - (i) below. In the sensor formation field for one piece of the p-Si substrate (silicon wafer) 1 As shown in drawing 2 (a), carry out the ion implantation of the p mold ion to the field which is going to form the dielectric detached cores 6 and 7 of the front face of the Si substrate 1, and the p+ field 11 is formed in it. The ion implantation of the p mold ion is carried out to

the field which is going to carry out the ion implantation of the n mold ion to the field which is going to form the sensor moving part 3 and the beam 4 in this p+ field 11, is going to form the n+ field 12 in it, and is going to form the piezoresistance 5 in the n+ field 12 in it further, and the p+ field 13 is formed in it. Moreover, the rear face of the Si substrate 1 is made to diffuse p mold dopant, and the p++ layer 14 is formed in it. Here, the p++ layer 14 turns into a rear-face side contact layer at the time of porosity Si formation.
[0045] subsequently, it is shown in drawing 2 (b) -- as -- the front face of the Si substrate 1 -- LPCVD -- by making SiN deposit by law (low voltage CVD method), the passivation film 8 is formed and opening of the aperture 15 is carried out to a part of part which touches the p+ field 11 of the passivation film 8 concerned. In addition, SiN deposited on the inferior surface of tongue of the Si substrate 1 at this time is removed.
[0046] Then, if the Si substrate 1 is immersed in HF (hydrogen fluoride) water solution and a current is passed between the p++ layer 14 of the Si substrate 1, and a counterelectrode (not shown) in HF water solution, as shown in drawing 2 (c), the p+ field 11 will change to porosity Si field 16A. Under the present circumstances, although a current flows from the p++ layer 14 used as a rear-face contact layer in the p+ field 11 which the part has exposed and it changes to porosity Si field 16A, since the p+ field 13 which is a piezoresistance 5 is covered by the passivation film (LPCVD-SiN) 8 and it does not become the path of a current of flowing in HF water solution from the p++ layer 14 on the back, it does not porosity-ize. Moreover, since the current density which flows to the field porosity-ized at this time, and the consistency of porosity Si field 16A have the relation of a profile inverse proportion, they use this phenomenon and form high density porosity Si field 17A in the opposite side the exposure side of the p+ field 11. Therefore, only the p+ field 11 is set to porosity Si field 16A or high density porosity Si field 17A. If the Si substrate 1 is made to oxidize thermally after forming porosity Si field 16A and high density porosity Si field 17A, as shown in drawing 2 (d), porosity Si field 16A currently embedded at the Si substrate 1 will change to SiO2 field 16B, and high density porosity Si field 17A will be set to high density SiO2 field 17B.
[0047] Subsequently, in the both ends of a piezoresistance 5 (p+ field 13), while forming the metal wiring 9 of a predetermined pattern by aluminum on the passivation film 8 as are shown in drawing 2 (e), and opening of the contact hole 10 is carried out to the passivation film 8 and it is shown in drawing 2 (f), the metal wiring 9 and a piezoresistance 5 are electrically connected through a contact hole 10. furthermore, it is shown in drawing 2 (g) -- as -- the plasma CVD (PECVD) from this top -- by making SiN deposit by law, the passivation film 18 for metal wiring protection is formed, opening of the contact hole 19 is carried out in the part which carries out patterning of the passivation film 18, and serves as an electrode pad of the metal wiring 9, and the passivation film 18 is calcinated.
[0048] Then, with the resist film 20, with a wrap, opening of the aperture 21 is carried out to the resist film 20 in the location which counters the whole with SiO2 field 16B, and the edge of SiO2 field 16B is exposed. subsequently, HF water solution, HF+NH4F water solution, etc. -- using -- BOE (buffer oxide etching) -- while carrying out etching removal of the SiO2 field 16B by law and forming the dielectric detached core 6 by the space after etching removal, the sensor moving part 3 and a beam 4 are formed by the n+ field 12 which remained. Moreover, the dielectric detached core 7 is formed by high density SiO2 field 17B which it left, without etching. Since high density SiO2 field 17B has the low etching rate as compared with other fields at this time, the permission width of face of etching time becomes large to the precision of a fixed etching distance, and it can make small configuration variation of the sensor moving part 3 by BOE etching.
[0049] According to this manufacture approach, by combining the porosity silicon formation process in HF water solution, a porosity Si oxidization process, and an oxidization Si etching process The dielectric detached cores 6 and 7 which become the Si substrate 1 from piezoresistance [of bulk Si] 5, sensor moving-part 3, space, and high density SiO2 film 17B can be formed. By the possibility of the elevated-temperature use beyond **150 degree C and ** high sensitivity, and the high resolution Acceleration-sensor A of a piezoresistance change detection method with the large detection range and the good temperature characteristic is producible.

[0050] Moreover, since the dielectric detached cores 6 and 7 are formed by forming a piezoresistance 5 in a beam 4, oxidizing the porosity Si fields 16A and 17A, and etching a part according to this manufacture approach, the factor which makes a gage factor small does not exist like the approach of forming a piezoresistance 5 according to the conventional web thinning process. Therefore, the gage factor of a piezoresistance 5 can be enlarged, it is high sensitivity and a high resolution, and the good property that the detection range is wide can be acquired. Moreover, two Si substrates are not needed like the conventional example, but since processes, such as the junction, web thinning, etc., are also unnecessary, cost can be made cheap.
[0051] What is shown in drawing 3 is the sectional view showing acceleration-sensor B by another example of this invention. If it is in this acceleration-sensor B, the weight section 26 which consists of a metal, polish recon, bulk silicon, a dielectric, etc. is separately formed on the sensor moving part 3 from on the passivation film 18, and the front face of the weight section 26 is further covered with the passivation film 27. If the weight section 26 is prepared for the sensor moving part 3 like this example, since the sensor moving part 3 will become easy to vibrate, the sensor sensibility to small acceleration can be raised.
[0052] What is shown in drawing 4 is the sectional view showing acceleration-sensor C by still more nearly another example of this invention. If it is in this acceleration-sensor C, thickness of the sensor moving part 3 is made larger than the thickness of a beam 4, and the weight section 26 of bulk silicon is formed in the inferior surface of tongue of the sensor moving part 3 at one. Even if it is in this example, the sensor sensibility to small acceleration can be raised by having formed the weight section 26.
[0053] What is shown in drawing 5 is the sectional view showing acceleration-sensor D by still more nearly another example of this invention. If it is in this acceleration-sensor D, one piece or two or more openings 28 which are penetrated up and down on the sensor moving part 3 and the passivation film 8 and 18 are prepared. Thus, by forming the opening 28 penetrated to the sensor moving part 3, air resistance in case the sensor moving part 3 displaces can be mitigated, and the fall of the sensor sensibility by air resistance can be prevented. That is, sensor sensibility can be raised.
[0054] What is shown in drawing 6 is the sectional view showing acceleration-sensor E by still more nearly another example of this invention. If it is in this acceleration-sensor E, the upper part of the sensor moving part 3 thru/or the whole crevice 2 is covered with the film 29 for the closures which consists of SiN, and the space 30 in which the sensor moving part 3 is located is closed. Moreover, space 30 is formed also between the top face of the sensor moving part 3, and the film 29 for the closures so that the variation rate of the sensor moving part 3 may not be barred with the film 29 for the closures. Even when the sensor moving part 3 does not contact the external world but uses it in a contamination ambient atmosphere since the closure of the sensor moving part 3 is carried out with the film 29 for the closures if it is in this acceleration sensor, contamination of the sensor moving part 3 can be prevented.
[0055] This film for the closures can be formed using the following silicon processing processes. namely, the field of the sensor moving part 3 after producing the acceleration sensor of structure like drawing 1 , a beam 4, and its perimeter -- a wrap -- the sacrifice layer (not shown) which makes it like and consists of glass ingredients, such as PSG, -- forming -- a sacrifice layer top -- PECVD -- the film 29 for the closures which consists of SiN by law is formed. then, opening of the film 29 for the closures which carried out opening of the film 29 for the closures in part, formed space 30 in the film 29 for the closures by removing a sacrifice layer from this opening by etching, and was opened previously -- PECVD -- SiN made to deposit by law closes.
[0056] What is shown in drawing 7 is the sectional view showing acceleration-sensor F by still more nearly another example of this invention. The upper part of the sensor moving part 3 is covered with the film 29 for the closures which consists of polish recon or SiN, and while closing the sensor moving part 3 with the film 29 for the closures, that closure space 31 is made to decompress, if it is in this acceleration-sensor F. If it is in this acceleration-sensor F, while being able to prevent contamination of the sensor moving part 3, sensor sensibility can be raised by reducing the air resistance of the sensor moving part 3.

[0057] After this film 29 for the closures forms the sacrifice layer (not shown) which consists of glass ingredients, such as PSG, The film 29 for the closures which consists of polish recon or SiN by law is formed. a sacrifice layer top -- LPCVD -- opening of the film 29 for the closures which formed the closure space 31 and opened it previously by carrying out opening of the film 29 for the closures in part, and carrying out etching removal of the sacrifice layer -- LECVD -- the polish recon made to deposit by law or SiN closes. Since acceleration-sensor F is in LP (low voltage) CVD system in case opening is closed, the closure space 31 in the film 29 for the closures is decompressed.
[0058] Drawing 8 (a) and (b) are the explanatory views showing a part of beam 4 which prepared the sectional view and piezoresistance 5 which show acceleration-sensor G by still more nearly another example of this invention, and which were fractured in part. If it is in this acceleration-sensor G, the conductive layer 32 which consists the field in which the piezoresistance 5 is formed of electrical conducting materials, such as a metal from the passivation film (dielectric film) 18 and doped polish recon, was formed, and the top face of a conductive layer 32 is further covered with the passivation film (dielectric film) 33. Furthermore, it is made to have joined to the Si substrate 1 electrically from the KONTOKUTO hole 35 which carried out opening of the tip of drawer Rhine 34 to the passivation film 18, and this conductive layer 32 makes the conductive layer 32 the Si substrate 1 and same electric potential (or touch-down potential). if it is in this acceleration-sensor G, since the conductive layer 32 into which the vertical side was inserted with the PASSHIBESHON film 33 and 18 is formed on the piezoresistance 5 -- this conductive layer 32 -- electromagnetism -- a noise -- it can shield -- the electromagnetism from the outside -- a noise -- winning popularity -- hard -- becoming -- electromagnetism -- it becomes strong in a noise.
[0059] Drawing 9 (a) and (b) are the explanatory views showing a part of beam 4 which prepared the sectional view and piezoresistance 5 which show acceleration-sensor H by still more nearly another example of this invention, and which were fractured in part. If it is in this acceleration-sensor H, as the top face of a piezoresistance 5 is made to contact directly, the thermal conductor layer 36 is formed in it. In a piezoresistance 5, if the variation in a temperature inclination or temperature is in each part, since an error will arise in a resistance output, by forming the thermal conductor layer 36 in the whole, the temperature inclination thru/or temperature variation in a piezoresistance 5 is made small, and a resistance output error can be made small. Therefore, the precision of acceleration-sensor H can be raised. As a thermal conductor layer 36, a metal layer with conductivity small (that is, resistivity is big), for example can be used. By using a metal layer, high thermal conductivity can be obtained and the resistance output error by the electric short circuit of piezoresistance 5 each part can also be prevented by moreover using a metal layer with small conductivity.
[0060] Drawing 10 is the sectional view showing acceleration-sensor J by still more nearly another example of this invention. In this acceleration-sensor J, in a part for the point of the sensor moving part 3, and the location which counters, as it was made to project from the Si substrate 1 to the crevice 2 upper part, the stopper 37 is formed in Si substrate 1 top face. A stopper 37 may be formed in one center section, may be formed in two both sides, or may be formed three or more pieces. Thus, since the sensor moving part 3 has deformation beyond it restricted by hitting a stopper 37 if the stopper 37 is formed in the Si substrate 1 when the sensor moving part 3 deforms greatly, the deformation of the sensor moving part 3 is restricted and it can prevent that the sensor moving part 3 thru/or a beam 4 are damaged according to excessive deformation.
[0061] What is shown in drawing 11 is drawing expanding and showing a part of beam 4 of the acceleration sensor by still more nearly another example of this invention. If it is in this example, the notching sections (notch) 38, such as the shape of the shape of V character and radii, are formed in the both sides of a part in which the piezoresistance 5 of a beam 4 is formed. Thus, a beam 4 can be made to generate stress concentration in the notching section 38 by forming the notching section 38 in a beam 4 [near the piezoresistance 5]. For this reason, as compared with a thing without the notching section 38, distortion of a beam 4 becomes large to the magnitude of the same acceleration, and the sensibility of an acceleration sensor improves.
[0062] Moreover, a beam 4 is made to generate stress concentration [near the piezoresistance 5], and in

order to enlarge distortion of a beam 4 and to raise sensor sensibility, as shown in drawing 12 , a through tube 39 and a hollow may be prepared in a beam 4 [near the piezoresistance 5].

[0063] What is shown in drawing 13 is drawing showing a part of acceleration-sensor K by still more nearly another example of this invention. In this example, the piezoresistance 5 is formed in the front face of the beam 4 which is supporting the sensor moving part 3, and the resistance 41 for constituting the resistance detector 40 with a piezoresistance 5 is formed in the front face of the Si substrate 1. Therefore, although, as for a piezoresistance 5, the resistance Rp of a piezoresistance 5 will change in connection with it if a beam 4 is distorted with the variation rate of the sensor moving part 3, resistance 41 is the constant resistance from which resistance R does not change depending on distortion of a beam 4. These piezoresistances 5 and resistance 41 have a bridge circuit as shown in drawing 14 with the circuit pattern on the Si substrate 1 constituted. In the resistance detector 40 which consists of this bridge circuit, constant current I is supplied between an input terminal 42 and 43, and the change in resistance of a piezoresistance 5 can be detected by detecting an output terminal 44 and the electrical potential difference V between 45.

[0064] Drawing 15 is drawing showing the other examples of a resistance detector, by four piezoresistances 5 formed on the beam 4, constitutes a bridge circuit and is inserting the resistance 46 for temperature compensation in a serial at each piezoresistance 5, respectively. This resistance 46 for temperature compensation is formed in the front face of the Si substrate 1 so that it may not be influenced according to deformation of a beam 4. And the resistance 46 for temperature compensation has a piezoresistance 5 and the reverse temperature characteristic (that is, the positive/negative of a temperature coefficient of variation is reverse), and when a piezoresistance 5 does not receive resistance change by distortion of a beam 4, even if temperature changes, sum Rp+Rc of the resistance Rp of a piezoresistance 5 and the resistance Rc of the resistance 46 for temperature compensation is kept almost constant. According to this resistance detector 47, only the change in resistance by distortion of a beam 4 can be detected, and it is hard coming to win popularity the effect of a temperature change.

[0065] Drawing 16 is drawing of a resistance detector showing other examples further, with the serial object of four piezoresistances 5 and resistance 48 for sensitivity settling, constitutes a bridge circuit and is inserting the resistance 49 for offset adjustment in any one branching. This resistance 48 for sensitivity settling and the resistance 49 for offset adjustment are formed in the front face of the Si substrate 1, and are variable resistance so that it may not be influenced according to deformation of a beam 4. According to this resistance detector 50, the sensibility of the resistance detector 50 can be adjusted by adjusting each resistance 48 for sensitivity settling. Moreover, by adjusting the resistance 49 for offset adjustment, when distortion of a beam 4 is 0, the amount of offset can be adjusted so that an output may be set to 0.

[0066] Drawing 17 is the top view showing acceleration-sensor L by still more nearly another example of this invention. In this acceleration-sensor L, two or more sensor moving part 3a-3e is arranged in the shape of an array to the Si substrate 1, and the piezoresistance 5 is formed in the beam 4 which supports each sensor moving part 3. Each sensor moving part 3a-3e has the sensibility to vibration of a different frequency. For example, each sensor moving part 3a-3e has sensibility which is expressed with the sensitivity curve of S1-S5 shown in drawing 18 . The output of the piezoresistance 5 prepared for such sensor moving part 3a-3e is superimposed and outputted, consequently as a continuous line shows the sensibility of the whole acceleration sensor to drawing 18 , the band of a sensitivity curve becomes large.

[0067] In addition, in the above-mentioned example, although the case of the acceleration sensor for detecting vibration and an impact was explained, it cannot be overemphasized that the piezoresistance change detection method sensor of this invention can be used as the sensor for detecting pressures other than acceleration and the physical quantity of the rate of flow and others, either.

[0068] It is the module M by still more nearly another example of this invention which is shown in drawing 19 . That is, it is the modules M, such as set components which unified the electrical and electric equipment, electronic parts, etc., and passive circuit elements which carried the electrical and electric equipment, electronic parts, etc. in the circuit board etc., and the piezoresistance change

detection method sensor 52 applied to this invention with the big device 51 of generation of heat, such as Power IC, is dedicated in this. Thus, since it will be equal also to elevated-temperature use of about 150 degrees C or more if the piezoresistance change detection method sensor 52 of this invention is used even when it really constitutes the piezoresistance change detection method sensor 52 as a module with the big device 51 of generation of heat, with the heat emitted from the big device 51 of generation of heat, a possibility that the piezoresistance change detection method sensor 52 may break down can be made small, and the dependability of Module M can be raised.

[0069] It is the device N with an oscillating detection function by still more nearly another example of this invention which is shown in drawing 20 , and it has attached the acceleration sensor 53 of the piezoresistance change detection method concerning this invention in the devices 54, such as a prime mover, a motor, a generator, disk breaking, and a machining machine. Although an installation location has a suitable location chosen according to the class of device 54, it is good to attach near the pad of disk breaking [**** /, and / attaching to the exterior of a generator direct picking], near the edge of a blade of a machining machine, etc. [attaching in the exterior and the interior of a prime mover or a motor directly, for example] When vibration of these devices can be detected with sufficient sensibility and a shimmy occurs by using the acceleration sensor 53 of this invention for these devices, it can detect immediately. And since the operating critical temperature is high, also with the heat of these devices 54, an acceleration sensor 53 cannot break down easily and the dependability of these devices 54 also improves.

[0070] What is shown in drawing 21 is the schematic diagram showing the boiler pressure detection equipment P by still more nearly another example of this invention, and has attached in the boiler 56 the pressure sensor 55 (for example, thing which detects the distortion of a diaphragm displaced by change of a pressure) of the piezoresistance change detection method concerning this invention. The steam of the boiler 56 interior is touched, or the steam of the boiler 56 interior is led to the pressure sensor 55, and the pressure sensor 55 can be made to carry out direct measurement of the boiler vapor pressure with a pressure sensor 55. Since the pressure sensor 55 of this invention also bears an elevated temperature 150 degrees C or more, it can use also for an application like a boiler 56. Moreover, you may make it detect not the pressure sensor 55 but an acceleration sensor for the shimmy of direct installation and a boiler 56 etc. on a boiler 56 as a sensor.

[0071] It is still more nearly another example of this invention which is shown in drawing 22 , and it is drawing showing the physical quantity detection equipment Q for elevated-temperature gases. In this example, the piezoresistance change detection method sensor 52 is attached in the outside of the tubing 57 which elevated-temperature gases, such as a steam, pass, and the piezoresistance change detection method sensor 52 is contacted into the elevated-temperature gas in tubing 57. Or the piezoresistance change detection method sensor 52 may be attached direct picking in tubing 57. And physical quantity, such as a pressure of an elevated-temperature gas, and the rate of flow, temperature, is detectable by this piezoresistance change detection method sensor 52. By using the piezoresistance change detection method sensor 52 of this invention also in this case, it becomes possible to detect physical quantity of an elevated-temperature gas 150 degrees C or more with sufficient sensibility. Moreover, since direct measurement becomes possible, without using the side duct which makes an elevated-temperature gas bypass for physical quantity measurement, a measurement error can be made small.

[0072] What is shown in drawing 23 is the schematic diagram showing the abnormal-condition detection equipment R by still more nearly another example of this invention. In this example, it has inputted into the signal-processing section 59, after attaching the piezoresistance change detection method sensor 52 in the devices 54, such as a prime mover, a motor, a generator, a machining machine, and a disk brake, and amplifying the output of the piezoresistance change detection method sensor 52 with amplifier 58. By performing fuzzy processing to the detecting signal of the piezoresistance change detection method sensor 52, the signal-processing section 59 is performing signal processing and decision, supervises the existence of the abnormalities of a device 54, and if it judges that abnormalities have occurred to the device 54, it will carry out feedback control of the device 54 so that a control signal may be outputted to a device 54 and abnormalities may be settled. Or the alarm thru/or warning which

tells abnormalities is outputted to the exterior from the signal-processing section 59.
[0073] If this abnormal-condition detection equipment R is explained concretely, as for the piezoresistance change detection method sensor 52 (for example, acceleration sensor), knocking of a prime mover will be detected as it is the case where a device 54 is a prime mover, for example. If the piezoresistance change detection method sensor 52 detects knocking, the signal-processing section will perform fuzzy processing to this detecting signal, and will avoid a knocking condition by outputting feedback signals, such as ignition timing modification.
[0074] Or when a device 54 is a diesel-type prime mover, the piezoresistance change detection method sensor 52 detects the scrap sound of a device 54, and when fuzzy processing is performed to this detecting signal and too much scrap sound is detected, the signal-processing section carries out feedback control of the prime mover so that a control signal may be outputted to a prime mover from the signal-processing section 59 and SUKURAPPINGU may be controlled.
[0075] Moreover, when a device 54 is a disk brake, the piezoresistance change detection method sensor 52 detects vibration of a disk brake, by performing fuzzy processing to this detecting signal, wear of a disk or a brake friction pad is detected, and an alarm signal can be outputted.
[0076] Moreover, when a device 54 is a machining machine, the piezoresistance change detection method sensor 52 attached near [the] the edge of a blade detects vibration etc., a control signal is outputted to a machining machine and tool exchange is made to detect the shimmy by the deficit of the edge of a blade, wear, etc., and to perform automatically, when the signal-processing section 59 performs fuzzy processing to the detecting signal. Or you may make it output warning.
[0077] Moreover, when a device 54 is a boiler, the abnormal combustion in a boiler can be detected by carrying out fuzzy processing of the detecting signal from the piezoresistance change detection method sensor 52 attached in the boiler in the signal-processing section 59. And if abnormal combustion is detected, a control signal can be outputted to a boiler so that it may become the amount of proper combustion, or warning can be outputted.
[0078] Moreover, when a device 54 is the device 54 which has tubing with which an elevated-temperature gas flows, fuzzy processing of the detecting signal from the piezoresistance change detection method sensor 52 attached in tubing is carried out in the signal-processing section 59, and it supervises whether the flow rate and pressure of an elevated-temperature gas in tubing have separated from the proper value. And detection of having separated from the proper value outputs a control signal to a device 54 so that it may become desired value.
[0079]
[Effect of the Invention] Since dielectric separation of the piezoresistance and substrate which consist of bulk silicon is carried out with the oxide film according to this invention, leakage current does not flow between a piezoresistance and a substrate and the use under hot environments is attained by even elevated temperature about 150 degrees C or more. And since dielectric separation is carried out by the insulator layer which made porosity silicon oxidize thermally, the gage factor of a piezoresistance does not fall in a production process. Consequently, the sensibility and resolution which are the advantage of bulk silicon resistance are high, and the advantage in which the detection range is wide can be employed efficiently. Consequently, the detection range large at ** high sensitivity and a high resolution in which the elevated-temperature use beyond **150 degree C is possible, and the piezoresistance change detection method sensor which has the good temperature characteristic are realizable.
[0080] Moreover, since two substrates are not needed but it can produce from one substrate, cost can also be made cheap.
[0081] In addition, there are the respectively following advantages in the following sensors. In this piezoresistance change detection method sensor, if the weight section is formed in sensor moving part, the sensibility to the detection physical quantity of a low input level can be raised.
[0082] Furthermore, if one piece or two or more openings are prepared for sensor moving part, sensor sensibility can be raised by mitigating the air resistance at the time of deformation of sensor moving part.
[0083] Moreover, if said sensor moving part is closed, sensor moving part can be intercepted with a

contamination ambient atmosphere, and a resistance to environment will improve. In that case, if the interior of closure is decompressed, air resistance will decrease and sensor sensibility will improve.
[0084] moreover -- if a conductive layer is formed in the top face of a piezoresistance and this conductive layer is made into a substrate and same electric potential -- electromagnetism -- a noise -- winning popularity -- being hard -- the S/N ratio of a piezoresistance change detection method sensor improves.
[0085] Or if the thermal conductor layer is directly formed on the piezoresistance, since the temperature inclination in a piezoresistance will become small, the resistance output error from a piezoresistance can be made small.
[0086] Moreover, if the stopper for restricting deformation of sensor moving part to a substrate is formed, breakage by the fault serious grade of sensor moving part can be prevented.
[0087] Furthermore, if the notching section or opening is prepared in the supporter which carries out elastic support of the sensor moving part, stress concentration will occur in the notching section or opening, as a result, the distortion of a supporter to the same input will become large, and sensor sensibility will improve.
[0088] Moreover, if the resistance detector for detecting the resistance of a piezoresistance is prepared on a substrate, a resistance detector is not needed separately but a piezoresistance change detection method sensor also including a resistance detector can be packed into a compact. Furthermore, if a piezoresistance and the resistance for temperature compensation of the reverse temperature characteristic are included in the resistance detector, the output change of a piezoresistance and the output change of the resistance for temperature compensation accompanying a temperature change can be made to be able to offset mutually, and the detection error by the temperature change can be made small. Or if offset resistance thru/or the resistance for sensitivity settling are prepared in the resistance detector, the offset value and detection sensitivity of a resistance detector can be adjusted.
[0089] Moreover, if two or more sensor moving part and two or more piezoresistances are prepared in the same substrate and the sensibility field of each sensor moving part is changed little by little, a sensibility field can be broadband-ized by making the sensibility of each sensor moving part superimpose.
[0090] Moreover, since the piezoresistance change detection method sensor of this invention has the above advantages, it can be used for the bottom of the hot environments in the module containing exoergic components like Power IC, a boiler, and tubing with which an elevated-temperature gas flows etc., and can detect high sensitivity also under such hot environments.
[0091] Moreover, vibration is detectable by high sensitivity by attaching in devices, such as a prime mover, a motor, a generator, a disk brake, and a machining machine, and further, if abnormalities are detected by performing fuzzy processing for this detecting signal in the signal-processing section, malfunction detection equipment usable also under hot environments can be obtained by high sensitivity.

[Translation done.]

* NOTICES *

TECHNICAL FIELD

[Industrial Application] This invention relates to a piezoresistance change detection method sensor. It is related with the piezoresistance change detection method sensor applied as various sensors for detecting physical quantity, such as force, a pressure, acceleration, the rate of flow, and a tilt angle, especially. Furthermore, it is related with the module equipped with the piezoresistance change detection method sensor, a device with an oscillating detection function, the physical quantity detection equipment of a boiler, the physical quantity detection equipment for gases, and abnormal-condition detection equipment.

[Translation done.]

PRIOR ART

[Description of the Prior Art] It is divided roughly into what used polish recon for electrical resistance materials, and the thing which used bulk silicon when the conventional piezoresistance change detection method sensor is seen from the point of the quality of the material of a piezoresistance.
[0003] (Piezoresistance change detection method sensor which used polish recon) If it is in the piezoresistance change detection method sensor which used polish recon as the quality of the material of a piezoresistance, since it is easy to form a detached core between a piezoresistance and a silicon substrate, and to carry out dielectric separation on the manufacture process, the piezoresistance by which dielectric separation was carried out with the silicon substrate is used. Therefore, by the sensor concerned, unless dielectric breakdown of a detached core occurs, between a silicon substrate and a piezoresistance, there is no possibility that a current may flow and even an elevated temperature 150 degrees C or more can be used. That is, it has the advantage in which the service temperature limitation by the side of an elevated temperature is high.
[0004] However, the piezoresistance (henceforth polish recon resistance) using polish recon has a small gage factor (resistance change to the amount of distortion comparatively) as compared with the piezoresistance (henceforth bulk silicon resistance) which used bulk silicon, and only about 1/5 resistance change of bulk silicon resistance usually breaks out to the same amount of distortion. For this reason, when the same configuration and the piezoresistance change detection method sensor of a configuration were manufactured, sensibility and resolving power were inferior to the piezoresistance change detection method sensor which used bulk silicon resistance in the piezoresistance change detection method sensor using polish recon resistance.
[0005] Moreover, since the destructive distortion of polish recon resistance was smaller than bulk silicon resistance, when the maximum distortion at the time of detection would be designed low and having been doubled with the lowness of detection sensitivity, there was a fault that the detection range of input physical quantity, such as a pressure and acceleration, will become narrow.
[0006] Furthermore, as compared with bulk silicon resistance, polish recon resistance is one with a large (usually about 5 times of bulk silicon resistance) temperature coefficient of resistance (TCR), and its change in resistance by temperature is large. For this reason, the piezoresistance change detection method sensor using polish recon resistance had the bad temperature characteristic, and it was unstable to the temperature change.
[0007] (Piezoresistance change detection method sensor which used bulk silicon) By the piezoresistance change detection method sensor which used bulk silicon, since sensibility and resolution are high since the gage factor of bulk silicon resistance is large as mentioned above as compared with polish recon resistance, and destructive distortion is also large, there is the advantage in which the detection range can be made large. Furthermore, since the temperature coefficient of resistance of bulk silicon resistance is small, the temperature characteristic is also good.
[0008] however, by the piezoresistance change detection method sensor using bulk silicon resistance Are performing separation with bulk silicon resistance and a silicon substrate by p-n junction, and moreover, since the p mold of the property of piezoresistances, such as a gage factor, is better and it is

common to maintain n layers of a silicon substrate to high potential Leakage current tended to flow on both sides of the detached core of p-n junction, and there was a fault with the as low service temperature limitation by the side of an elevated temperature as about 150 degrees C under hot environments (150 degrees C or more).
[0009] For this reason, a piezoresistance change detection method sensor which are ** high sensitivity and a high resolution, and fills to coincidence two demands that the detection range has a high service temperature limitation in ** elevated-temperature side with the goodness of the property of being large is desired.
[0010] Then, in order to satisfy these two demands to coincidence, the manufacture approach as shown in drawing 24 is proposed. This manufacture approach is explained according to drawing 24 . It is two Si substrates (silicon wafer) 81 and 82 which are shown in drawing 24 (a), and by driving p mold ion, such as boron, into the inferior surface of tongue of one Si substrate 81, the p++ layer 83 used as a piezoresistance 85 is formed, and the oxide film (SiO2 film) 84 is formed in the top face of the Si substrate 82 of another side. After joining the Si substrate 81 of each other in piles on this Si substrate 82 (drawing 24 (b)) and joining, etching removal of the upper Si substrate 81 is carried out using alkali etchant, such as KOH. At this time, as the p++ layer 83 remains on the Si substrate 82, without being etched since the etching rate is smaller than the Si substrate 81 and it is shown in drawing 24 (c), a piezoresistance 85 is formed on an oxide film 84.
[0011] Then, an SiN film is formed in the inferior surface of tongue of the Si substrate 82 with a low voltage CVD method, and the mask 86 for anisotropic etching is formed by carrying out patterning of the SiN film (drawing 24 (d)). Moreover, a piezoresistance 85 is made to flow in the top face of the Si substrate 82, metal wiring 87 is given to it (drawing 24 (e)), and the passivation film 88 is further formed in it with glass ingredients, such as PSG, (drawing 24 (f)). Subsequently, the part exposed from the mask 86 is deleted to the thickness of a beam 89 by performing anisotropic etching to the Si substrate 82 from an inferior-surface-of-tongue side (drawing 24 (g)). Furthermore, a beam 89 and the sensor moving part 90 are formed by leaving the part used as a beam 89 and carrying out opening of other parts for a thin-walled part by etching (drawing 24 (h)).

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Since dielectric separation of the piezoresistance and substrate which consist of bulk silicon is carried out with the oxide film according to this invention, leakage current does not flow between a piezoresistance and a substrate and the use under hot environments is attained by even elevated temperature about 150 degrees C or more. And since dielectric separation is carried out by the insulator layer which made porosity silicon oxidize thermally, the gage factor of a piezoresistance does not fall in a production process. Consequently, the sensibility and resolution which are the advantage of bulk silicon resistance are high, and the advantage in which the detection range is wide can be employed efficiently. Consequently, the detection range large at ** high sensitivity and a high resolution in which the elevated-temperature use beyond **150 degree C is possible, and the piezoresistance change detection method sensor which has the good temperature characteristic are realizable.
[0080] Moreover, since two substrates are not needed but it can produce from one substrate, cost can also be made cheap.
[0081] In addition, there are the respectively following advantages in the following sensors. In this piezoresistance change detection method sensor, if the weight section is formed in sensor moving part, the sensibility to the detection physical quantity of a low input level can be raised.
[0082] Furthermore, if one piece or two or more openings are prepared for sensor moving part, sensor sensibility can be raised by mitigating the air resistance at the time of deformation of sensor moving part.
[0083] Moreover, if said sensor moving part is closed, sensor moving part can be intercepted with a contamination ambient atmosphere, and a resistance to environment will improve. In that case, if the interior of closure is decompressed, air resistance will decrease and sensor sensibility will improve.
[0084] moreover -- if a conductive layer is formed in the top face of a piezoresistance and this conductive layer is made into a substrate and same electric potential -- electromagnetism -- a noise -- winning popularity -- being hard -- the S/N ratio of a piezoresistance change detection method sensor improves.
[0085] Or if the thermal conductor layer is directly formed on the piezoresistance, since the temperature inclination in a piezoresistance will become small, the resistance output error from a piezoresistance can be made small.
[0086] Moreover, if the stopper for restricting deformation of sensor moving part to a substrate is formed, breakage by the fault serious grade of sensor moving part can be prevented.
[0087] Furthermore, if the notching section or opening is prepared in the supporter which carries out elastic support of the sensor moving part, stress concentration will occur in the notching section or opening, as a result, the distortion of a supporter to the same input will become large, and sensor sensibility will improve.
[0088] Moreover, if the resistance detector for detecting the resistance of a piezoresistance is prepared on a substrate, a resistance detector is not needed separately but a piezoresistance change detection method sensor also including a resistance detector can be packed into a compact. Furthermore, if a piezoresistance and the resistance for temperature compensation of the reverse temperature

characteristic are included in the resistance detector, the output change of a piezoresistance and the output change of the resistance for temperature compensation accompanying a temperature change can be made to be able to offset mutually, and the detection error by the temperature change can be made small. Or if offset resistance thru/or the resistance for sensitivity settling are prepared in the resistance detector, the offset value and detection sensitivity of a resistance detector can be adjusted.
[0089] Moreover, if two or more sensor moving part and two or more piezoresistances are prepared in the same substrate and the sensibility field of each sensor moving part is changed little by little, a sensibility field can be broadband-ized by making the sensibility of each sensor moving part superimpose.
[0090] Moreover, since the piezoresistance change detection method sensor of this invention has the above advantages, it can be used for the bottom of the hot environments in the module containing exoergic components like Power IC, a boiler, and tubing with which an elevated-temperature gas flows etc., and can detect high sensitivity also under such hot environments.
[0091] Moreover, vibration is detectable by high sensitivity by attaching in devices, such as a prime mover, a motor, a generator, a disk brake, and a machining machine, and further, if abnormalities are detected by performing fuzzy processing for this detecting signal in the signal-processing section, malfunction detection equipment usable also under hot environments can be obtained by high sensitivity.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] If it is in the acceleration sensor 91 manufactured as mentioned above, the piezoresistance 85 which separates with an oxide film 84 and consists of bulk silicon is formed in the top face of a beam 89. Therefore, it insulates with the oxide film 84, and a piezoresistance 85 and the Si substrate 82 do not have a fear of leakage current flowing between a piezoresistance 85 and the Si substrate 82, and become usable also in an elevated temperature 150 degrees C or more.
[0013] However, in order to make it only a piezoresistance 85 remain by predetermined thickness like drawing 24 (c) when etching the upper Si substrate 81 after joining two Si substrates 81 and 82, without a piezoresistance 85 being etched by alkali etchant, it is necessary to enlarge the ion injection rate to the p++ layer 83 (piezoresistance 85). However, when carried out that the ion injection rate to the p++ layer 83 is enlarged, and it is hard to be etched, a gage factor was not able to be made not much high. Therefore, the advantage of bulk silicon resistance that the detection range is wide was not able to be efficiently employed by high sensitivity and the high resolution.
[0014] Moreover, in order to obtain one acceleration sensor 91, two Si substrates 81 and 82 were needed, and there was a fault that the process which joins two Si substrates 81 and 82, and the process which carries out web thinning until it becomes the thickness for about one sheet about the joined Si substrates 81 and 82 were needed, the yield of a product was bad, and cost cost dearly, further.
[0015] Therefore, it is ** high sensitivity and a high resolution, and two demands that the detection range had a high service temperature limitation in ** elevated-temperature side with the goodness of the property of being large were not able to be filled with the conventional piezoresistance change detection method sensor to coincidence.
[0016] The place which this invention is made in view of the fault of the above-stated conventional example, and is made into the purpose is by carrying out dielectric separation of the piezoresistance and sensor moving part which consist of bulk silicon with a substrate with an oxide film to offer the piezoresistance change detection method sensor which fills two demands, the above-mentioned ** and **, to coincidence.

[Translation done.]

MEANS

[Means for Solving the Problem] The piezoresistance change detection method sensor of this invention is characterized by carrying out dielectric separation with the oxide film which was made to oxidize porosity silicon thermally and formed said piezoresistance which consists of bulk silicon, and said substrate.
[0018] Moreover, the weight section may be formed in said sensor moving part in the above-mentioned piezoresistance change detection method sensor. Or one piece or two or more openings may be prepared for said sensor moving part. Furthermore, said sensor moving part may be closed. In that case, the interior of closure may be decompressed.
[0019] Moreover, in the above-mentioned piezoresistance change detection method sensor, the conductive layer which consists of electrical conducting materials, such as a metal and doped polish recon, on both sides of a dielectric film may be formed in the top face of said piezoresistance, and this conductive layer may be made into a substrate and same electric potential. Or a thermal conductor layer with good thermal conductivity may be directly formed on said piezoresistance.
[0020] Moreover, in the above-mentioned piezoresistance change detection method sensor, the stopper for restricting deformation of sensor moving part to said substrate may be formed. Furthermore, said piezoresistance may be prepared in the supporter which carries out elastic support of said sensor moving part, and the notching section or opening may be prepared in said supporter [near the piezoresistance].
[0021] Moreover, a resistance detector can be established in the above-mentioned piezoresistance change detection method sensor. In that case, said piezoresistance and resistance of the reverse temperature characteristic are prepared on said substrate, and you may make it make the property change by temperature compensate by constituting said a part of resistance detector from this resistance. Or offset resistance thru/or the resistance for sensitivity settling may be prepared on said substrate, and said a part of resistance detector may consist of this offset resistance thru/or resistance for sensitivity settling.

[0022] Furthermore, two or more sensor moving part and two or more piezoresistances may be prepared in said substrate.
[0023] Moreover, the module of this invention is characterized by combining exoergic components like Power IC, and the above-mentioned piezoresistance change detection method sensor.
[0024] Moreover, the device with an oscillating detection function of this invention is characterized by attaching the above-mentioned piezoresistance change detection method sensor in devices, such as a prime mover, a motor, a generator, a disk brake, and a machining machine.
[0025] Moreover, the physical quantity detection equipment of the boiler of this invention is characterized by making it make a boiler detect physical quantity, such as vibration of direct installation and a boiler and a pressure, for the above-mentioned piezoresistance change detection method sensor.
[0026] Moreover, the physical quantity detection equipment for gases of this invention is attached in tubing with which elevated-temperature gases, such as a steam, pass the above-mentioned piezoresistance change detection method sensor, and is characterized by making it make physical quantity, such as a pressure of an elevated-temperature gas, and the rate of flow, detect.

[0027] Moreover, the abnormal-condition detection equipment of this invention is characterized by having a signal-processing means to detect abnormalities by performing fuzzy processing to the detecting signal of the above-mentioned piezoresistance change detection method sensor and said sensor.

[Translation done.]

OPERATION

[Function] If it is in the piezoresistance change detection method sensor of this invention, since dielectric separation of the piezoresistance and substrate which consist of bulk silicon is carried out with the oxide film, leakage current does not flow between a piezoresistance and a substrate and the use under hot environments is attained by even elevated temperature about 150 degrees C or more. Moreover, if it is in this invention, since the insulator layer for dielectric separation is formed by making porosity silicon oxidize thermally, after embedding a piezoresistance at sensor moving part thru/or its supporting section, the field of the perimeter is formed into porosity silicon, by oxidizing thermally further, an oxide film can be formed and dielectric separation of a piezoresistance and the substrate can be carried out. Therefore, using two substrates, a piezoresistance is piled up with the substrate of another side on the oxide film of one substrate, and the gage factor of a piezoresistance does not fall in a production process like the conventional example which forms a piezoresistance on an oxide film with web thinning. Consequently, the sensibility and resolution which are the advantage of bulk silicon resistance are high, and the advantage in which the detection range is wide can be employed efficiently. Consequently, the detection range large at ** high sensitivity and a high resolution in which the elevated-temperature use beyond **150 degree C is possible, and the piezoresistance change detection method sensor which has the good temperature characteristic are realizable.
[0029] Moreover, since two substrates are not needed like the conventional piezoresistance change detection method sensor shown in drawing 24 but it can produce from one substrate, cost can also be made cheap.
[0030] Moreover, in this piezoresistance change detection method sensor, if the weight section is formed in sensor moving part, the sensibility to the detection physical quantity of a low input level can be raised.
[0031] Furthermore, if one piece or two or more openings are prepared for sensor moving part, sensor sensibility can be raised by mitigating the air resistance at the time of deformation of sensor moving part.
[0032] Moreover, if said sensor moving part is closed, sensor moving part can be intercepted with a contamination ambient atmosphere, and a resistance to environment will improve. In that case, if the interior of closure is decompressed, air resistance will decrease and sensor sensibility will improve.
[0033] moreover -- if a conductive layer is formed in the top face of a piezoresistance and this conductive layer is made into a substrate and same electric potential -- electromagnetism -- a noise -- winning popularity -- being hard -- the S/N ratio of a piezoresistance change detection method sensor improves.
[0034] Or if the thermal conductor layer is directly formed on the piezoresistance, since the temperature inclination in a piezoresistance will become small, the resistance output error from a piezoresistance can be made small.
[0035] Moreover, if the stopper for restricting deformation of sensor moving part to a substrate is formed, breakage by the fault serious grade of sensor moving part can be prevented.
[0036] Furthermore, if the notching section or opening is prepared in the supporter which carries out

elastic support of the sensor moving part, stress concentration will occur in the notching section or opening, as a result, the distortion of a supporter to the same input will become large, and sensor sensibility will improve.

[0037] Moreover, if the resistance detector for detecting the resistance of a piezoresistance is prepared on a substrate, a resistance detector is not needed separately but a piezoresistance change detection method sensor also including a resistance detector can be packed into a compact. Furthermore, if a piezoresistance and the resistance for temperature compensation of the reverse temperature characteristic are included in the resistance detector, the output change of a piezoresistance and the output change of the resistance for temperature compensation accompanying a temperature change can be made to be able to offset mutually, and the detection error by the temperature change can be made small. Or if offset resistance thru/or the resistance for sensitivity settling are prepared in the resistance detector, the offset value and detection sensitivity of a resistance detector can be adjusted.

[0038] Moreover, if two or more sensor moving part and two or more piezoresistances are prepared in the same substrate and the sensibility field of each sensor moving part is changed little by little, a sensibility field can be broadband-ized by making the sensibility of each sensor moving part superimpose.

[0039] Moreover, since the piezoresistance change detection method sensor of this invention has the above advantages, it can be used for the bottom of the hot environments in the module containing exoergic components like Power IC, a boiler, and tubing with which an elevated-temperature gas flows etc., and can detect high sensitivity also under such hot environments.

[0040] Moreover, vibration is detectable by high sensitivity by attaching in devices, such as a prime mover, a motor, a generator, a disk brake, and a machining machine, and further, if abnormalities are detected by performing fuzzy processing for this detecting signal in the signal-processing section, malfunction detection equipment usable also under hot environments can be obtained by high sensitivity.

[Translation done.]

EXAMPLE

[Example] Drawing 1 is the perspective view showing acceleration-sensor A of the piezoresistance change detection method by one example of this invention fractured in part. 1 is a p-Si substrate and the rectangle-like crevice 2 is cut in the top face of the Si substrate 1. n -- The sensor moving part 3 which consists of bulk Si is dedicated in the crevice 2 in the condition of having floated in the air, and is supported by the Si substrate 1 by two level beams 4. Therefore, if the sensor moving part 3 senses and displaces acceleration, vibration, an impact, etc., a beam 4 will carry out elastic deformation. The piezoresistance 5 which consists of p+-bulk Si is formed in the surface of a beam 4, and the deformation amount of a beam 4 is detected as resistance change of a piezoresistance 5. Therefore, the acceleration which joins the sensor moving part 3 by the change in resistance of a piezoresistance 5, vibration, an impact, etc. are detected.
[0042] Moreover, dielectric separation of the sensor moving part 3, a beam 4, and a piezoresistance 5 and the Si substrate 1 is carried out by the dielectric detached core. That is, the dielectric detached core 6 which consists of air (dielectric) is formed in the space between the sensor moving part 3 and a beam 4, and the Si substrate 1 (crevice 2 inside). Furthermore, the dielectric detached core 7 which the field which is supporting the beam 4 of the edge of a crevice 2 becomes from the silicon oxide ($SiO2$) film is formed. Therefore, the sensor moving part 3 has structure which had the end face section of a beam 4 supported by the dielectric detached core 7 embedded in the Si substrate 1, dielectric separation of the sensor moving part 3 and the beam 4 is completely carried out from the Si substrate 1, and even an elevated temperature 150 degrees C or more does not have a possibility that leakage current may flow between a piezoresistance 5 and the Si substrate 1.
[0043] Furthermore, the Si substrate 1, the sensor moving part 3, the beam 4, and the front face of a piezoresistance 5 are covered with the passivation film 8 which consists of silicon nitride (SiN), and the metal wiring 9 of aluminum formed on the passivation film 8 is electrically connected to the passivation film 8 to the both ends of a piezoresistance 5 through the contact hole 10 which carried out opening. In addition, the passivation film which consists of SiN further may be formed on this.
[0044] Below, the manufacture approach of the above-mentioned acceleration-sensor A is explained. The manufacture approach of this acceleration-sensor A (the structure of metal wiring differs from the acceleration sensor of drawing 1 a little.) is shown in drawing 2 (a) - (i), and the manufacture approach concerned is explained according to drawing 2 (a) - (i) below. In the sensor formation field for one piece of the p-Si substrate (silicon wafer) 1 As shown in drawing 2 (a), carry out the ion implantation of the p mold ion to the field which is going to form the dielectric detached cores 6 and 7 of the front face of the Si substrate 1, and the p+ field 11 is formed in it. The ion implantation of the p mold ion is carried out to the field which is going to carry out the ion implantation of the n mold ion to the field which is going to form the sensor moving part 3 and the beam 4 in this p+ field 11, is going to form the n+ field 12 in it, and is going to form the piezoresistance 5 in the n+ field 12 in it further, and the p+ field 13 is formed in it. Moreover, the rear face of the Si substrate 1 is made to diffuse p mold dopant, and the p++ layer 14 is formed in it. Here, the p++ layer 14 turns into a rear-face side contact layer at the time of porosity Si formation.

[0045] subsequently, it is shown in drawing 2 (b) -- as -- the front face of the Si substrate 1 -- LPCVD -- by making SiN deposit by law (low voltage CVD method), the passivation film 8 is formed and opening of the aperture 15 is carried out to a part of part which touches the p+ field 11 of the passivation film 8 concerned. In addition, SiN deposited on the inferior surface of tongue of the Si substrate 1 at this time is removed.
[0046] Then, if the Si substrate 1 is immersed in HF (hydrogen fluoride) water solution and a current is passed between the p++ layer 14 of the Si substrate 1, and a counterelectrode (not shown) in HF water solution, as shown in drawing 2 (c), the p+ field 11 will change to porosity Si field 16A. Under the present circumstances, although a current flows from the p++ layer 14 used as a rear-face contact layer in the p+ field 11 which the part has exposed and it changes to porosity Si field 16A, since the p+ field 13 which is a piezoresistance 5 is covered by the passivation film (LPCVD-SiN) 8 and it does not become the path of a current of flowing in HF water solution from the p++ layer 14 on the back, it does not porosity-ize. Moreover, since the current density which flows to the field porosity-ized at this time, and the consistency of porosity Si field 16A have the relation of a profile inverse proportion, they use this phenomenon and form high density porosity Si field 17A in the opposite side the exposure side of the p+ field 11. Therefore, only the p+ field 11 is set to porosity Si field 16A or high density porosity Si field 17A. If the Si substrate 1 is made to oxidize thermally after forming porosity Si field 16A and high density porosity Si field 17A, as shown in drawing 2 (d), porosity Si field 16A currently embedded at the Si substrate 1 will change to SiO2 field 16B, and high density porosity Si field 17A will be set to high density SiO2 field 17B.
[0047] Subsequently, in the both ends of a piezoresistance 5 (p+ field 13), while forming the metal wiring 9 of a predetermined pattern by aluminum on the passivation film 8 as are shown in drawing 2 (e), and opening of the contact hole 10 is carried out to the passivation film 8 and it is shown in drawing 2 (f), the metal wiring 9 and a piezoresistance 5 are electrically connected through a contact hole 10. furthermore, it is shown in drawing 2 (g) -- as -- the plasma CVD (PECVD) from this top -- by making SiN deposit by law, the passivation film 18 for metal wiring protection is formed, opening of the contact hole 19 is carried out in the part which carries out patterning of the passivation film 18, and serves as an electrode pad of the metal wiring 9, and the passivation film 18 is calcinated.
[0048] Then, with the resist film 20, with a wrap, opening of the aperture 21 is carried out to the resist film 20 in the location which counters the whole with SiO2 field 16B, and the edge of SiO2 field 16B is exposed. subsequently, HF water solution, HF+NH4F water solution, etc. -- using -- BOE (buffer oxide etching) -- while carrying out etching removal of the SiO2 field 16B by law and forming the dielectric detached core 6 by the space after etching removal, the sensor moving part 3 and a beam 4 are formed by the n+ field 12 which remained. Moreover, the dielectric detached core 7 is formed by high density SiO2 field 17B which it left, without etching. Since high density SiO2 field 17B has the low etching rate as compared with other fields at this time, the permission width of face of etching time becomes large to the precision of a fixed etching distance, and it can make small configuration variation of the sensor moving part 3 by BOE etching.
[0049] According to this manufacture approach, by combining the porosity silicon formation process in HF water solution, a porosity Si oxidization process, and an oxidization Si etching process The dielectric detached cores 6 and 7 which become the Si substrate 1 from piezoresistance [of bulk Si] 5, sensor moving-part 3, space, and high density SiO2 film 17B can be formed. By the possibility of the elevated-temperature use beyond **150 degree C and ** high sensitivity, and the high resolution Acceleration-sensor A of a piezoresistance change detection method with the large detection range and the good temperature characteristic is producible.
[0050] Moreover, since the dielectric detached cores 6 and 7 are formed by forming a piezoresistance 5 in a beam 4, oxidizing the porosity Si fields 16A and 17A, and etching a part according to this manufacture approach, the factor which makes a gage factor small does not exist like the approach of forming a piezoresistance 5 according to the conventional web thinning process. Therefore, the gage factor of a piezoresistance 5 can be enlarged, it is high sensitivity and a high resolution, and the good property that the detection range is wide can be acquired. Moreover, two Si substrates are not needed

like the conventional example, but since processes, such as the junction, web thinning, etc., are also unnecessary, cost can be made cheap.
[0051] What is shown in drawing 3 is the sectional view showing acceleration-sensor B by another example of this invention. If it is in this acceleration-sensor B, the weight section 26 which consists of a metal, polish recon, bulk silicon, a dielectric, etc. is separately formed on the sensor moving part 3 from on the passivation film 18, and the front face of the weight section 26 is further covered with the passivation film 27. If the weight section 26 is prepared for the sensor moving part 3 like this example, since the sensor moving part 3 will become easy to vibrate, the sensor sensibility to small acceleration can be raised.
[0052] What is shown in drawing 4 is the sectional view showing acceleration-sensor C by still more nearly another example of this invention. If it is in this acceleration-sensor C, thickness of the sensor moving part 3 is made larger than the thickness of a beam 4, and the weight section 26 of bulk silicon is formed in the inferior surface of tongue of the sensor moving part 3 at one. Even if it is in this example, the sensor sensibility to small acceleration can be raised by having formed the weight section 26.
[0053] What is shown in drawing 5 is the sectional view showing acceleration-sensor D by still more nearly another example of this invention. If it is in this acceleration-sensor D, one piece or two or more openings 28 which are penetrated up and down on the sensor moving part 3 and the passivation film 8 and 18 are prepared. Thus, by forming the opening 28 penetrated to the sensor moving part 3, air resistance in case the sensor moving part 3 displaces can be mitigated, and the fall of the sensor sensibility by air resistance can be prevented. That is, sensor sensibility can be raised.
[0054] What is shown in drawing 6 is the sectional view showing acceleration-sensor E by still more nearly another example of this invention. If it is in this acceleration-sensor E, the upper part of the sensor moving part 3 thru/or the whole crevice 2 is covered with the film 29 for the closures which consists of SiN, and the space 30 in which the sensor moving part 3 is located is closed. Moreover, space 30 is formed also between the top face of the sensor moving part 3, and the film 29 for the closures so that the variation rate of the sensor moving part 3 may not be barred with the film 29 for the closures. Even when the sensor moving part 3 does not contact the external world but uses it in a contamination ambient atmosphere since the closure of the sensor moving part 3 is carried out with the film 29 for the closures if it is in this acceleration sensor, contamination of the sensor moving part 3 can be prevented.
[0055] This film for the closures can be formed using the following silicon processing processes. namely, the field of the sensor moving part 3 after producing the acceleration sensor of structure like drawing 1 , a beam 4, and its perimeter -- a wrap -- the sacrifice layer (not shown) which makes it like and consists of glass ingredients, such as PSG, -- forming -- a sacrifice layer top -- PECVD -- the film 29 for the closures which consists of SiN by law is formed. then, opening of the film 29 for the closures which carried out opening of the film 29 for the closures in part, formed space 30 in the film 29 for the closures by removing a sacrifice layer from this opening by etching, and was opened previously -- PECVD -- SiN made to deposit by law closes.
[0056] What is shown in drawing 7 is the sectional view showing acceleration-sensor F by still more nearly another example of this invention. The upper part of the sensor moving part 3 is covered with the film 29 for the closures which consists of polish recon or SiN, and while closing the sensor moving part 3 with the film 29 for the closures, that closure space 31 is made to decompress, if it is in this acceleration-sensor F. If it is in this acceleration-sensor F, while being able to prevent contamination of the sensor moving part 3, sensor sensibility can be raised by reducing the air resistance of the sensor moving part 3.
[0057] After this film 29 for the closures forms the sacrifice layer (not shown) which consists of glass ingredients, such as PSG, The film 29 for the closures which consists of polish recon or SiN by law is formed. a sacrifice layer top -- LPCVD -- opening of the film 29 for the closures which formed the closure space 31 and opened it previously by carrying out opening of the film 29 for the closures in part, and carrying out etching removal of the sacrifice layer -- LECVD -- the polish recon made to deposit by law or SiN closes. Since acceleration-sensor F is in LP (low voltage) CVD system in case opening is

closed, the closure space 31 in the film 29 for the closures is decompressed.
[0058] Drawing 8 (a) and (b) are the explanatory views showing a part of beam 4 which prepared the sectional view and piezoresistance 5 which show acceleration-sensor G by still more nearly another example of this invention, and which were fractured in part. If it is in this acceleration-sensor G, the conductive layer 32 which consists the field in which the piezoresistance 5 is formed of electrical conducting materials, such as a metal from the passivation film (dielectric film) 18 and doped polish recon, was formed, and the top face of a conductive layer 32 is further covered with the passivation film (dielectric film) 33. Furthermore, it is made to have joined to the Si substrate 1 electrically from the KONTOKUTO hole 35 which carried out opening of the tip of drawer Rhine 34 to the passivation film 18, and this conductive layer 32 makes the conductive layer 32 the Si substrate 1 and same electric potential (or touch-down potential). if it is in this acceleration-sensor G, since the conductive layer 32 into which the vertical side was inserted with the PASSHIBESHON film 33 and 18 is formed on the piezoresistance 5 -- this conductive layer 32 -- electromagnetism -- a noise -- it can shield -- the electromagnetism from the outside -- a noise -- winning popularity -- hard -- becoming -- electromagnetism -- it becomes strong in a noise.
[0059] Drawing 9 (a) and (b) are the explanatory views showing a part of beam 4 which prepared the sectional view and piezoresistance 5 which show acceleration-sensor H by still more nearly another example of this invention, and which were fractured in part. If it is in this acceleration-sensor H, as the top face of a piezoresistance 5 is made to contact directly, the thermal conductor layer 36 is formed in it. In a piezoresistance 5, if the variation in a temperature inclination or temperature is in each part, since an error will arise in a resistance output, by forming the thermal conductor layer 36 in the whole, the temperature inclination thru/or temperature variation in a piezoresistance 5 is made small, and a resistance output error can be made small. Therefore, the precision of acceleration-sensor H can be raised. As a thermal conductor layer 36, a metal layer with conductivity small (that is, resistivity is big), for example can be used. By using a metal layer, high thermal conductivity can be obtained and the resistance output error by the electric short circuit of piezoresistance 5 each part can also be prevented by moreover using a metal layer with small conductivity.
[0060] Drawing 10 is the sectional view showing acceleration-sensor J by still more nearly another example of this invention. In this acceleration-sensor J, in a part for the point of the sensor moving part 3, and the location which counters, as it was made to project from the Si substrate 1 to the crevice 2 upper part, the stopper 37 is formed in Si substrate 1 top face. A stopper 37 may be formed in one center section, may be formed in two both sides, or may be formed three or more pieces. Thus, since the sensor moving part 3 has deformation beyond it restricted by hitting a stopper 37 if the stopper 37 is formed in the Si substrate 1 when the sensor moving part 3 deforms greatly, the deformation of the sensor moving part 3 is restricted and it can prevent that the sensor moving part 3 thru/or a beam 4 are damaged according to excessive deformation.
[0061] What is shown in drawing 11 is drawing expanding and showing a part of beam 4 of the acceleration sensor by still more nearly another example of this invention. If it is in this example, the notching sections (notch) 38, such as the shape of the shape of V character and radii, are formed in the both sides of a part in which the piezoresistance 5 of a beam 4 is formed. Thus, a beam 4 can be made to generate stress concentration in the notching section 38 by forming the notching section 38 in a beam 4 [near the piezoresistance 5]. For this reason, as compared with a thing without the notching section 38, distortion of a beam 4 becomes large to the magnitude of the same acceleration, and the sensibility of an acceleration sensor improves.
[0062] Moreover, a beam 4 is made to generate stress concentration [near the piezoresistance 5], and in order to enlarge distortion of a beam 4 and to raise sensor sensibility, as shown in drawing 12 , a through tube 39 and a hollow may be prepared in a beam 4 [near the piezoresistance 5].
[0063] What is shown in drawing 13 is drawing showing a part of acceleration-sensor K by still more nearly another example of this invention. In this example, the piezoresistance 5 is formed in the front face of the beam 4 which is supporting the sensor moving part 3, and the resistance 41 for constituting the resistance detector 40 with a piezoresistance 5 is formed in the front face of the Si substrate 1.

Therefore, although, as for a piezoresistance 5, the resistance Rp of a piezoresistance 5 will change in connection with it if a beam 4 is distorted with the variation rate of the sensor moving part 3, resistance 41 is the constant resistance from which resistance R does not change depending on distortion of a beam 4. These piezoresistances 5 and resistance 41 have a bridge circuit as shown in drawing 14 with the circuit pattern on the Si substrate 1 constituted. In the resistance detector 40 which consists of this bridge circuit, constant current I is supplied between an input terminal 42 and 43, and the change in resistance of a piezoresistance 5 can be detected by detecting an output terminal 44 and the electrical potential difference V between 45.

[0064] Drawing 15 is drawing showing the other examples of a resistance detector, by four piezoresistances 5 formed on the beam 4, constitutes a bridge circuit and is inserting the resistance 46 for temperature compensation in a serial at each piezoresistance 5, respectively. This resistance 46 for temperature compensation is formed in the front face of the Si substrate 1 so that it may not be influenced according to deformation of a beam 4. And the resistance 46 for temperature compensation has a piezoresistance 5 and the reverse temperature characteristic (that is, the positive/negative of a temperature coefficient of variation is reverse), and when a piezoresistance 5 does not receive resistance change by distortion of a beam 4, even if temperature changes, sum Rp+Rc of the resistance Rp of a piezoresistance 5 and the resistance Rc of the resistance 46 for temperature compensation is kept almost constant. According to this resistance detector 47, only the change in resistance by distortion of a beam 4 can be detected, and it is hard coming to win popularity the effect of a temperature change.

[0065] Drawing 16 is drawing of a resistance detector showing other examples further, with the serial object of four piezoresistances 5 and resistance 48 for sensitivity settling, constitutes a bridge circuit and is inserting the resistance 49 for offset adjustment in any one branching. This resistance 48 for sensitivity settling and the resistance 49 for offset adjustment are formed in the front face of the Si substrate 1, and are variable resistance so that it may not be influenced according to deformation of a beam 4. According to this resistance detector 50, the sensibility of the resistance detector 50 can be adjusted by adjusting each resistance 48 for sensitivity settling. Moreover, by adjusting the resistance 49 for offset adjustment, when distortion of a beam 4 is 0, the amount of offset can be adjusted so that an output may be set to 0.

[0066] Drawing 17 is the top view showing acceleration-sensor L by still more nearly another example of this invention. In this acceleration-sensor L, two or more sensor moving part 3a-3e is arranged in the shape of an array to the Si substrate 1, and the piezoresistance 5 is formed in the beam 4 which supports each sensor moving part 3. Each sensor moving part 3a-3e has the sensibility to vibration of a different frequency. For example, each sensor moving part 3a-3e has sensibility which is expressed with the sensitivity curve of S1-S5 shown in drawing 18 . The output of the piezoresistance 5 prepared for such sensor moving part 3a-3e is superimposed and outputted, consequently as a continuous line shows the sensibility of the whole acceleration sensor to drawing 18 , the band of a sensitivity curve becomes large.

[0067] In addition, in the above-mentioned example, although the case of the acceleration sensor for detecting vibration and an impact was explained, it cannot be overemphasized that the piezoresistance change detection method sensor of this invention can be used as the sensor for detecting pressures other than acceleration and the physical quantity of the rate of flow and others, either.

[0068] It is the module M by still more nearly another example of this invention which is shown in drawing 19 . That is, it is the modules M, such as set components which unified the electrical and electric equipment, electronic parts, etc., and passive circuit elements which carried the electrical and electric equipment, electronic parts, etc. in the circuit board etc., and the piezoresistance change detection method sensor 52 applied to this invention with the big device 51 of generation of heat, such as Power IC, is dedicated in this. Thus, since it will be equal also to elevated-temperature use of about 150 degrees C or more if the piezoresistance change detection method sensor 52 of this invention is used even when it really constitutes the piezoresistance change detection method sensor 52 as a module with the big device 51 of generation of heat, with the heat emitted from the big device 51 of generation of heat, a possibility that the piezoresistance change detection method sensor 52 may break down can be

made small, and the dependability of Module M can be raised.
[0069] It is the device N with an oscillating detection function by still more nearly another example of this invention which is shown in drawing 20 , and it has attached the acceleration sensor 53 of the piezoresistance change detection method concerning this invention in the devices 54, such as a prime mover, a motor, a generator, disk breaking, and a machining machine. Although an installation location has a suitable location chosen according to the class of device 54, it is good to attach near the pad of disk breaking [**** /, and / attaching to the exterior of a generator direct picking], near the edge of a blade of a machining machine, etc. [attaching in the exterior and the interior of a prime mover or a motor directly, for example] When vibration of these devices can be detected with sufficient sensibility and a shimmy occurs by using the acceleration sensor 53 of this invention for these devices, it can detect immediately. And since the operating critical temperature is high, also with the heat of these devices 54, an acceleration sensor 53 cannot break down easily and the dependability of these devices 54 also improves.
[0070] What is shown in drawing 21 is the schematic diagram showing the boiler pressure detection equipment P by still more nearly another example of this invention, and has attached in the boiler 56 the pressure sensor 55 (for example, thing which detects the distortion of a diaphragm displaced by change of a pressure) of the piezoresistance change detection method concerning this invention. The steam of the boiler 56 interior is touched, or the steam of the boiler 56 interior is led to the pressure sensor 55, and the pressure sensor 55 can be made to carry out direct measurement of the boiler vapor pressure with a pressure sensor 55. Since the pressure sensor 55 of this invention also bears an elevated temperature 150 degrees C or more, it can use also for an application like a boiler 56. Moreover, you may make it detect not the pressure sensor 55 but an acceleration sensor for the shimmy of direct installation and a boiler 56 etc. on a boiler 56 as a sensor.
[0071] It is still more nearly another example of this invention which is shown in drawing 22 , and it is drawing showing the physical quantity detection equipment Q for elevated-temperature gases. In this example, the piezoresistance change detection method sensor 52 is attached in the outside of the tubing 57 which elevated-temperature gases, such as a steam, pass, and the piezoresistance change detection method sensor 52 is contacted into the elevated-temperature gas in tubing 57. Or the piezoresistance change detection method sensor 52 may be attached direct picking in tubing 57. And physical quantity, such as a pressure of an elevated-temperature gas, and the rate of flow, temperature, is detectable by this piezoresistance change detection method sensor 52. By using the piezoresistance change detection method sensor 52 of this invention also in this case, it becomes possible to detect physical quantity of an elevated-temperature gas 150 degrees C or more with sufficient sensibility. Moreover, since direct measurement becomes possible, without using the side duct which makes an elevated-temperature gas bypass for physical quantity measurement, a measurement error can be made small.
[0072] What is shown in drawing 23 is the schematic diagram showing the abnormal-condition detection equipment R by still more nearly another example of this invention. In this example, it has inputted into the signal-processing section 59, after attaching the piezoresistance change detection method sensor 52 in the devices 54, such as a prime mover, a motor, a generator, a machining machine, and a disk brake, and amplifying the output of the piezoresistance change detection method sensor 52 with amplifier 58. By performing fuzzy processing to the detecting signal of the piezoresistance change detection method sensor 52, the signal-processing section 59 is performing signal processing and decision, supervises the existence of the abnormalities of a device 54, and if it judges that abnormalities have occurred to the device 54, it will carry out feedback control of the device 54 so that a control signal may be outputted to a device 54 and abnormalities may be settled. Or the alarm thru/or warning which tells abnormalities is outputted to the exterior from the signal-processing section 59.
[0073] If this abnormal-condition detection equipment R is explained concretely, as for the piezoresistance change detection method sensor 52 (for example, acceleration sensor), knocking of a prime mover will be detected as it is the case where a device 54 is a prime mover, for example. If the piezoresistance change detection method sensor 52 detects knocking, the signal-processing section will perform fuzzy processing to this detecting signal, and will avoid a knocking condition by outputting

feedback signals, such as ignition timing modification.
[0074] Or when a device 54 is a diesel-type prime mover, the piezoresistance change detection method sensor 52 detects the scrap sound of a device 54, and when fuzzy processing is performed to this detecting signal and too much scrap sound is detected, the signal-processing section carries out feedback control of the prime mover so that a control signal may be outputted to a prime mover from the signal-processing section 59 and SUKURAPPINGU may be controlled.
[0075] Moreover, when a device 54 is a disk brake, the piezoresistance change detection method sensor 52 detects vibration of a disk brake, by performing fuzzy processing to this detecting signal, wear of a disk or a brake friction pad is detected, and an alarm signal can be outputted.
[0076] Moreover, when a device 54 is a machining machine, the piezoresistance change detection method sensor 52 attached near [the] the edge of a blade detects vibration etc., a control signal is outputted to a machining machine and tool exchange is made to detect the shimmy by the deficit of the edge of a blade, wear, etc., and to perform automatically, when the signal-processing section 59 performs fuzzy processing to the detecting signal. Or you may make it output warning.
[0077] Moreover, when a device 54 is a boiler, the abnormal combustion in a boiler can be detected by carrying out fuzzy processing of the detecting signal from the piezoresistance change detection method sensor 52 attached in the boiler in the signal-processing section 59. And if abnormal combustion is detected, a control signal can be outputted to a boiler so that it may become the amount of proper combustion, or warning can be outputted.
[0078] Moreover, when a device 54 is the device 54 which has tubing with which an elevated-temperature gas flows, fuzzy processing of the detecting signal from the piezoresistance change detection method sensor 52 attached in tubing is carried out in the signal-processing section 59, and it supervises whether the flow rate and pressure of an elevated-temperature gas in tubing have separated from the proper value. And detection of having separated from the proper value outputs a control signal to a device 54 so that it may become desired value.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the perspective view showing the acceleration sensor of the piezoresistance change detection method by one example of this invention.
[Drawing 2] (a), (b), (c), (d), (e), (f), (g), (h), and (i) are the sectional views showing the manufacture approach of an acceleration sensor same as the above.
[Drawing 3] It is the sectional view showing the acceleration sensor by another example of this invention.
[Drawing 4] It is the sectional view showing the acceleration sensor by still more nearly another example of this invention.
[Drawing 5] It is the sectional view showing the acceleration sensor by still more nearly another example of this invention.
[Drawing 6] It is the sectional view showing the acceleration sensor by still more nearly another example of this invention.
[Drawing 7] It is the sectional view showing the acceleration sensor by still more nearly another example of this invention.
[Drawing 8] The sectional view showing the acceleration sensor according [(a)] to still more nearly another example of this invention fractured in part and (b) are the explanatory views showing a part of the beam.
[Drawing 9] The sectional view showing the acceleration sensor according [(a)] to still more nearly another example of this invention fractured in part and (b) are the explanatory views showing a part of the beam.
[Drawing 10] It is the sectional view showing the acceleration sensor by still more nearly another example of this invention.
[Drawing 11] It is the top view showing a part of beam of the acceleration sensor by still more nearly another example of this invention.
[Drawing 12] It is the top view showing a part of beam of the acceleration sensor by still more nearly another example of this invention.
[Drawing 13] It is an acceleration sensor by still more nearly another example of this invention, and is the top view showing the piezoresistance and constant resistance which constitute a resistance detector.
[Drawing 14] It is the circuit diagram showing a resistance detector same as the above.
[Drawing 15] It is the circuit diagram showing the other examples of a resistance detector.
[Drawing 16] It is the circuit diagram of a resistance detector showing other examples further.
[Drawing 17] It is the top view showing the acceleration sensor by still more nearly another example of this invention.
[Drawing 18] It is an operation explanatory view same as the above.
[Drawing 19] It is the schematic diagram showing still more nearly another example of this invention.
[Drawing 20] It is the schematic diagram showing still more nearly another example of this invention.
[Drawing 21] It is the schematic diagram showing still more nearly another example of this invention.

[Drawing 22] It is the schematic diagram showing still more nearly another example of this invention.
[Drawing 23] It is the schematic diagram showing still more nearly another example of this invention.
[Drawing 24] (a), (b), (c), (d), (e), (f), (g), and (h) are the sectional views showing the manufacture approach of the acceleration sensor by the conventional example.

[Description of Notations]

1 Si Substrate
3 Sensor Moving Part
4 Beam
5 Piezoresistance
6 Dielectric Detached Core (Space)
7 Dielectric Detached Core (Oxide Film)
16A Porosity Si field
16B SiO2 field
17A High density porosity Si field
17B High density SiO2 field
26 Weight Section
28 Opening
29 Film for Closures
32 Conductive Layer
36 Thermal Conductor Layer
37 Stopper
38 Notching Section
39 Through Tube

[Translation done.]

* NOTICES *

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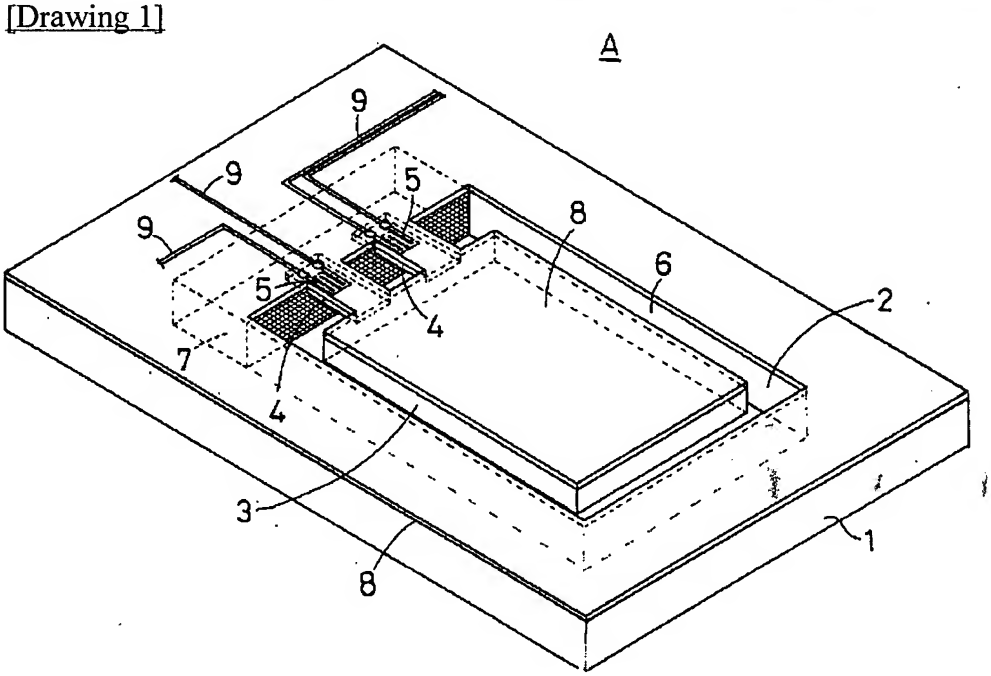
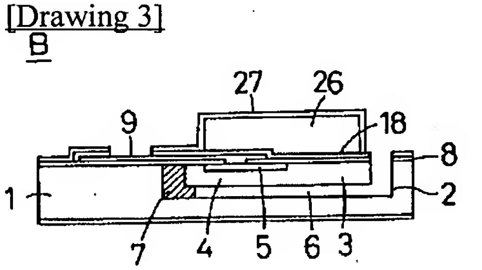
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

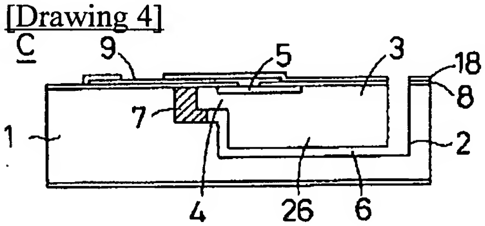
[Drawing 1]



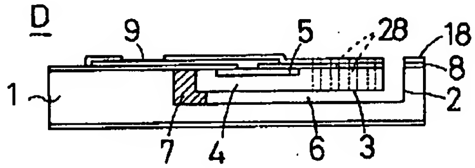
[Drawing 3]



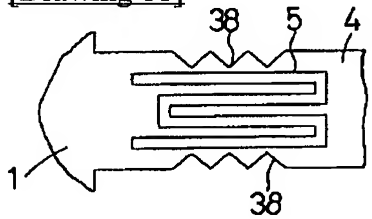
[Drawing 4]



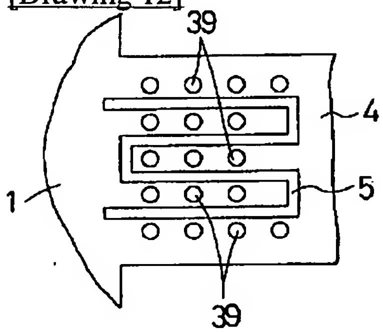
[Drawing 5]



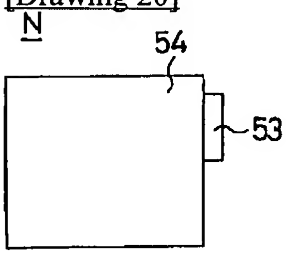
[Drawing 11]



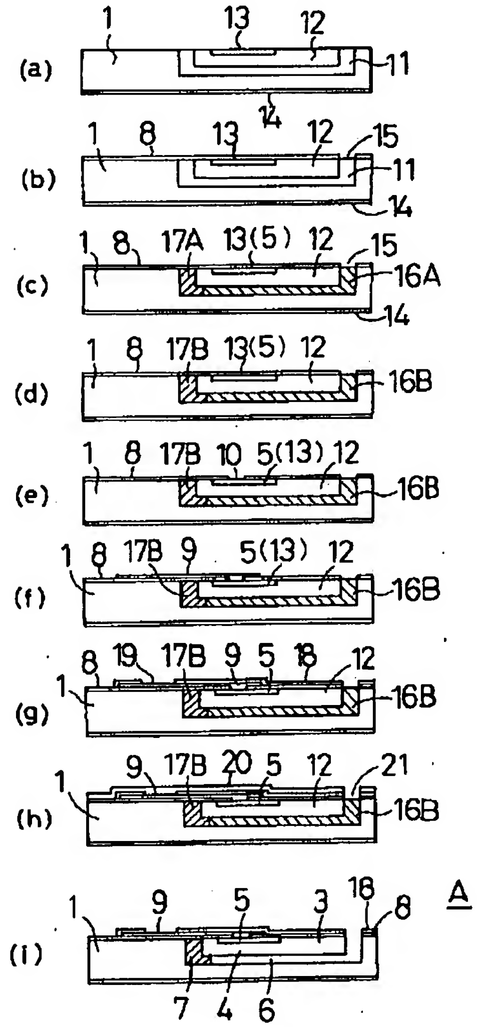
[Drawing 12]



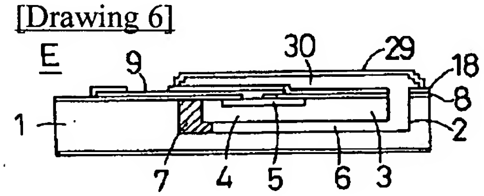
[Drawing 20]



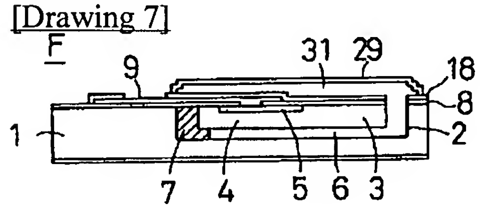
[Drawing 2]



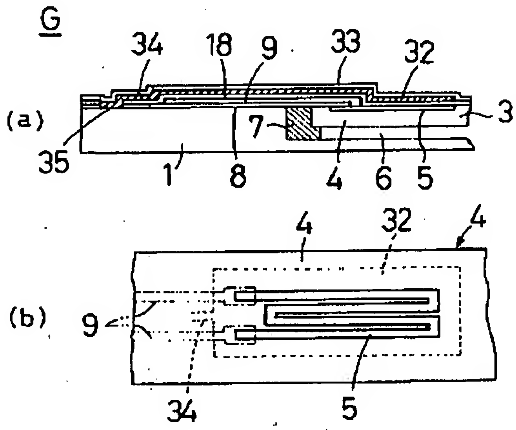
[Drawing 6]



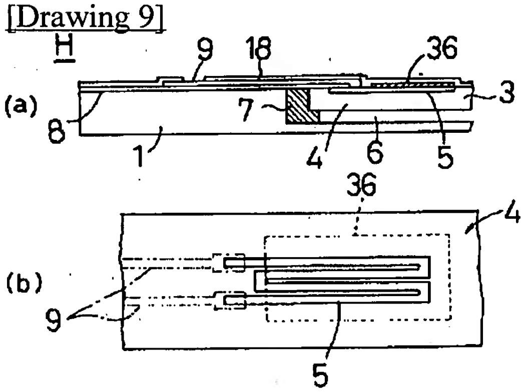
[Drawing 7]



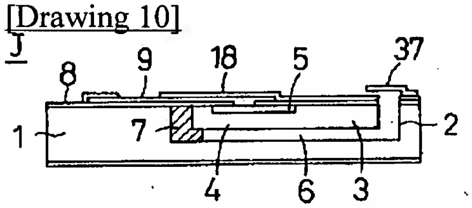
[Drawing 8]



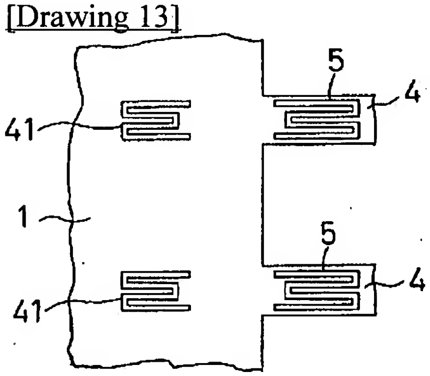
[Drawing 9]



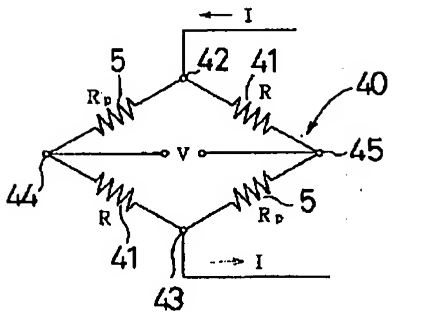
[Drawing 10]



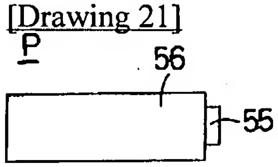
[Drawing 13]



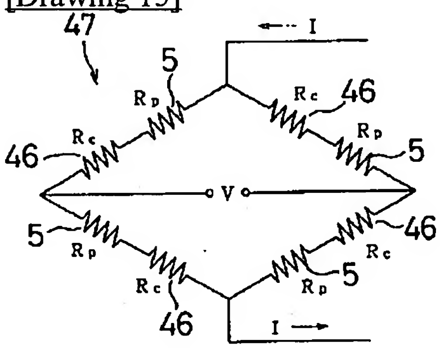
[Drawing 14]



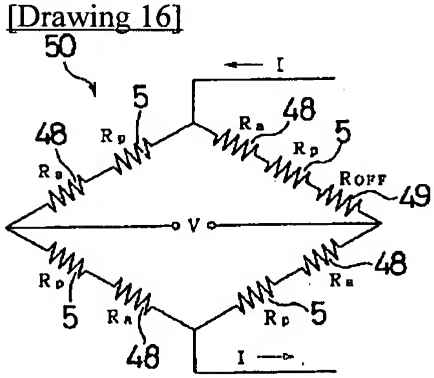
[Drawing 21]



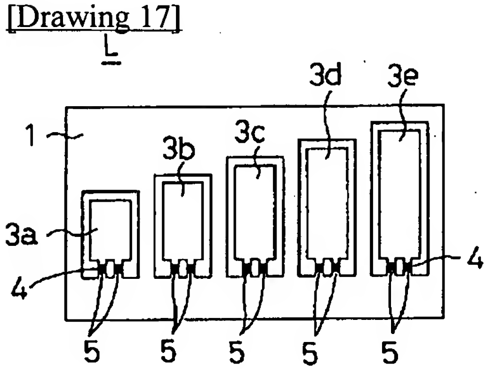
[Drawing 15]



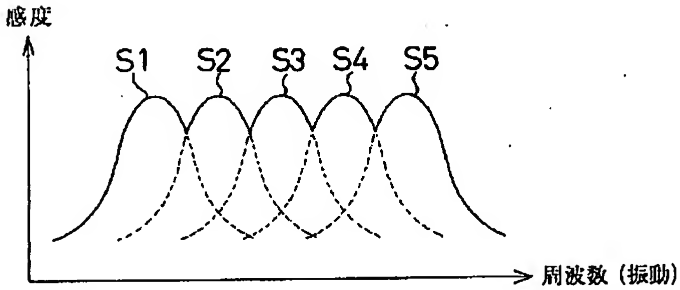
[Drawing 16]



[Drawing 17]

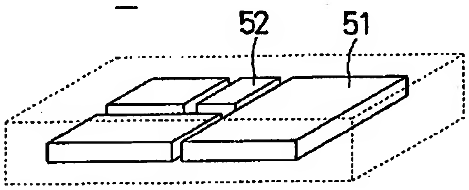


[Drawing 18]



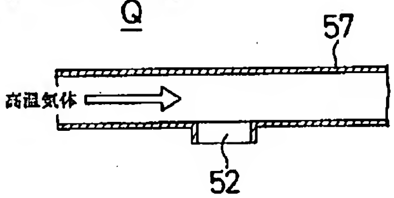
[Drawing 19]

M



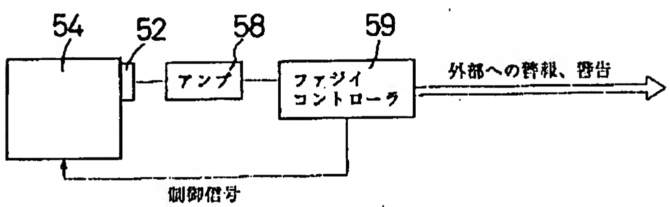
[Drawing 22]

Q

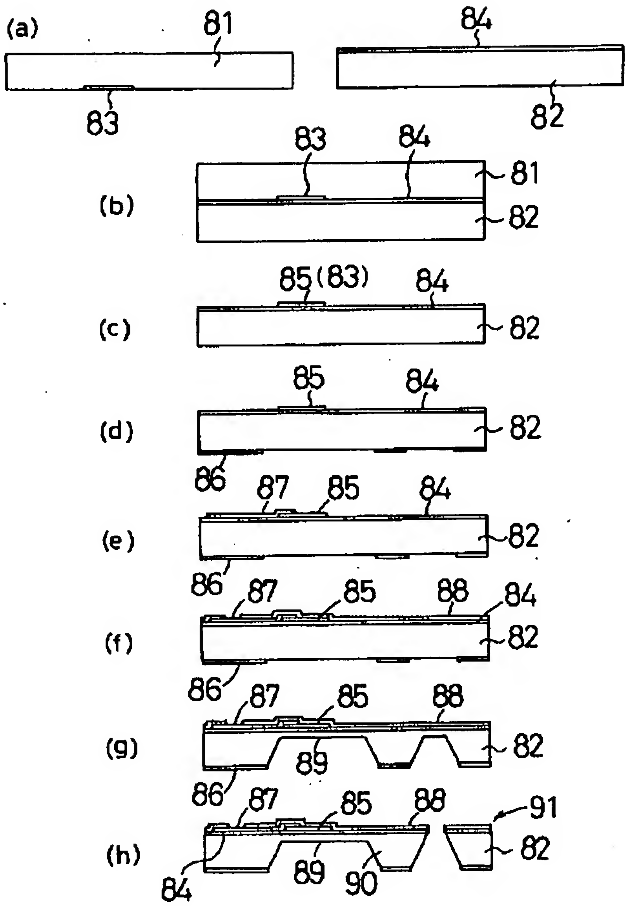


[Drawing 23]

R



[Drawing 24]



[Translation done.]